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A SUMMARY OF THE GEOLOGY OF EASTERN MASSACHUSETTS,(U)
JUL 75 F W FESSENDEN, J AYERS, S L DEAN

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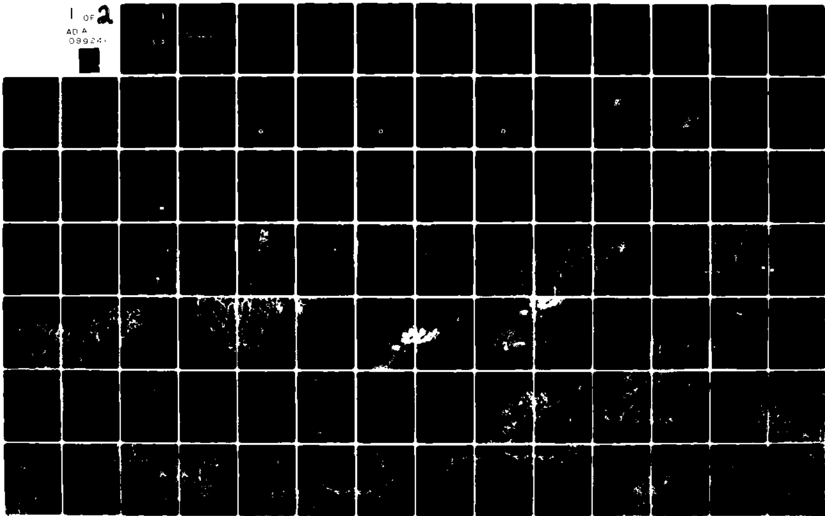

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A SUMMARY

OF

THE GEOLOGY OF

EASTERN MASSACHUSETTS

Prepared as a Planning Document

for Wastewater Management Studies

NEW ENGLAND DIVISION CORPS OF ENGINEERS

JULY 1975

A SUMMARY OF THE GEOLOGY OF EASTERN MASSACHUSETTS

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Corps of Engineers

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Whitman & Howard, Inc.

March 1975
Corps of Engineers
Planning Division
New England Division

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A SUMMARY OF THE GEOLOGY OF EASTERN MASSACHUSETTS

I. INTRODUCTION

The Corps of Engineers, along with other State and Federal agencies, has conducted broad-based studies of wastewater in eastern Massachusetts. A major portion of this study dealt with the feasibility and planning procedures for different methods of wastewater treatment and renovation in accordance with the goals expressed in Public Law 92-500. One of the alternatives studied was that of wastewater treatment by the method of land application. In this alternative, wastewater is applied to the ground and is treated as it flows on or through the soil and underlying rock material.

Knowledge of the geology of an area is of prime concern to any planning effort for land application of wastewater. The effectiveness of land treatment and the impact of the applied wastewater on the land, groundwater, and nearby streams and other surface bodies cannot be adequately addressed unless the surficial, groundwater and general bedrock geology of an area are known. To this end, the geology of eastern Massachusetts was compiled from existing sources and was displayed in both narrative and map form. The entire wastewater management study was divided into two parts based on geographic delineation. One study dealt with the Merrimack Valley in Massachusetts, the other with the rest of the State of Massachusetts east of approximately the 71°, 52', 30" W longitude. The compilation of the geology of the Merrimack Valley in Massachusetts was prepared by Goldberg-Zoino and Associates, Inc. under the direction of Mr. John Ayres. The geology of the rest of the study area was compiled by Whitman and Howard, Inc., under the supervision of Mr. Steven Dean. The two efforts were coordinated by the senior author of this report, Franklin W. Fessenden of Bentley College and the Corps of Engineers.

The full description of the geologic investigations can be found in the main reports on each of the two study areas. The Merrimack Study is in Appendix I-A (Geologic - Hydrogeologic Investigations) of Volume 3, "Merrimack Wastewater Management, Key to a Clean River." The Eastern Massachusetts geology study is printed as an Addendum to the Boston Harbor -- Eastern Massachusetts Metropolitan Area Wastewater Study. Both of these reports were published by and are on file at the Corps of Engineers, New England Division.

This report is a summary of the two major geologic studies and is intended for those who wish a set of geologic maps of the Eastern Massachusetts area along with a list of source materials and references compiled in one volume. It should be emphasized that the material presented in this report is a compilation of available geologic knowledge existing prior to late 1973 and does not include original research.

II. LOCATION

The area discussed in this report is that portion of the Commonwealth of Massachusetts east of longitude 71°, 52', 30". The study area has been subdivided into two regions, the Merrimack River Basin in Massachusetts and the remaining part of the eastern half of the State outside of the Merrimack Basin. Figure 1 is a location map of the entire study area with the subdivision outlined.

III. SUMMARY OF THE GEOLOGY OF THE STUDY AREA

A. Bedrock Geology

The bedrock of the study area consists of igneous, sedimentary and metamorphic rocks mantled discontinuously by unconsolidated deposits. The ages of the bedrock range from pre-Cambrian to late Paleozoic with some minor volcanics of Triassic age also being mapped. The predominate igneous rocks are granite and granodiorite. Other igneous rocks mapped are syenites, volcanics and gabbrodiorities. Outcrops of sedimentary and metasedimentary rocks of chiefly confined to the eastern and south-eastern parts of the study area in the Boston and Narragansett basins. Slates, argillites and conglomerates as well as some sandstones are mapped. Metamorphic rocks exhibiting both foliated (phyllites, schists, and genisses) and non-foliated (quartzites) texture are abundant and outcrop in all parts of the study area.

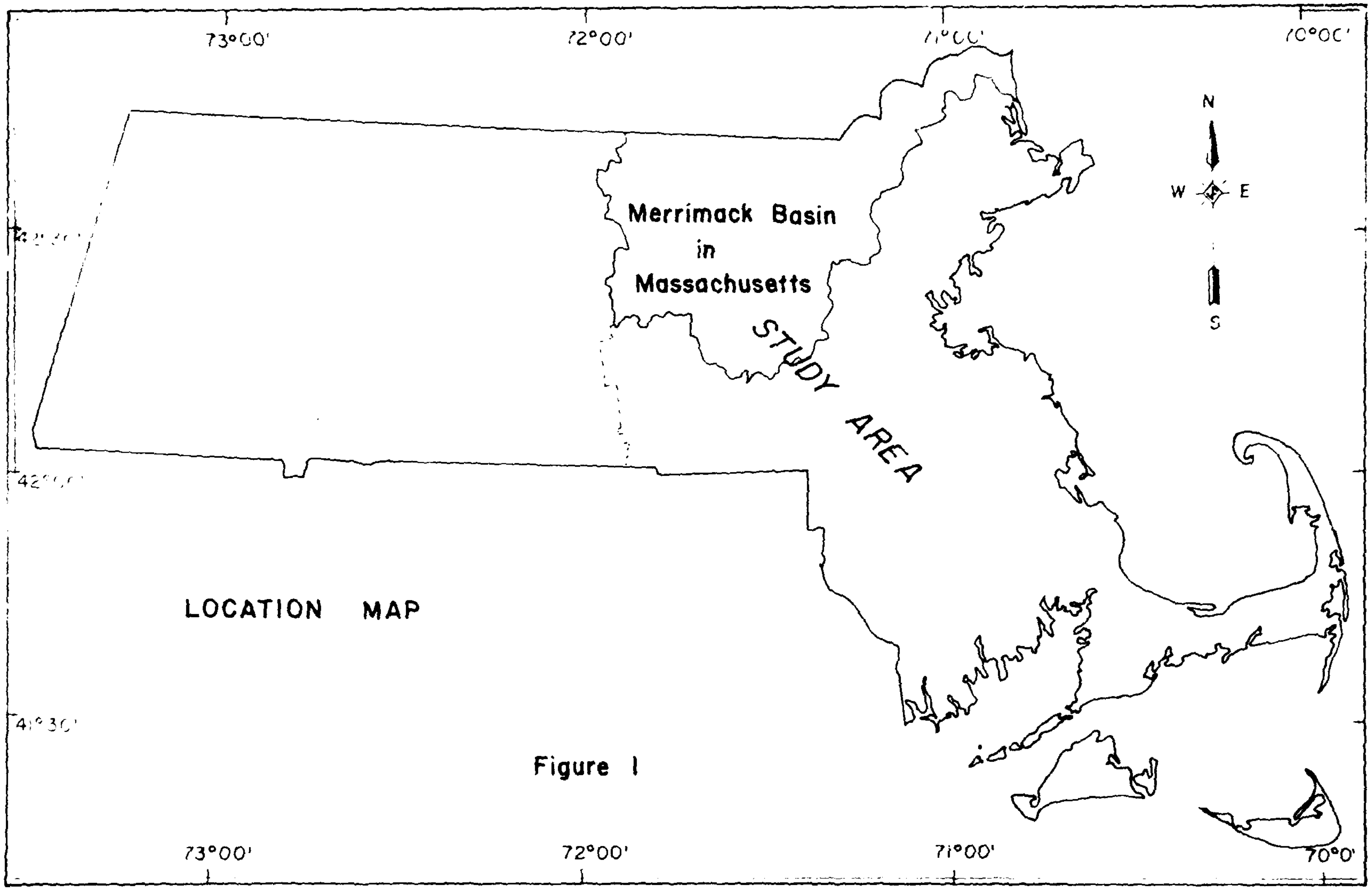
B. Surficial Geology

1. General

Nearly all of the bedrock units of the study area are of Paleozoic age or older. The exceptions are a few diabase dikes of reported Triassic age. A long period of erosion followed the emplacement of the bedrock. During this interval, the rock was weathered and worn away and streams and rivers incised valleys in the bedrock floor.

Downcutting by these streams was interrupted by the advance and retreat of glacial ice sheets during the Pleistocene epoch. Much of the mantling cover of soil and weathered rock was removed by the ice sheets, and the underlying bedrock surfaces were subjected to glacial abrasion and scouring.

One or more layers of till or other glacial debris was deposited on this modified surface by the advancing ice. Later, as the ice melted, waterborne drift accumulated between, among, and over residual ice blocks, and settled in the basins of temporary glacial lakes.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S
Merrimack Basin
in
Massachusetts
STUDY AREA
LOCATION MAP

Figure 1

Pre-glacial drainage patterns changed as many of the ancient pre-glacial valleys were blocked or filled with sediment and the streams, having been diverted from their original channels, developed new courses.

After the glacial ice had receded, the land mass began to rebound exposing some of the newly-deposited materials to further erosion. During and following this period, sea level fluctuated with the strand line first retreating and then re-advancing. Along the shores glacial sands were shaped into dunes by the wind, open waters were filled with sediments and on these a marsh system evolved.

Landward, the large glacial lakes were drained to the sea through successively lower elevation outlets. Rivers and streams became established in new courses and channels, and glacial-derived sediments were commonly reworked and redeposited as alluvium. Poorly drained upland areas and old lake bottoms, along with some of the deeper kettle holes in outwash areas, became partially filled with organic detritus.

2. Glacial Deposits

With the exception of local deposits of Tertiary clays and silts and sands along the south shore and the islands, all the various unconsolidated surficial materials in the study area are of Pleistocene or recent age. Several different types, grouped by lithologic character and mode of origin, are present in the area.

Glacial Till

Till is the most widespread unconsolidated sediment. It consists for the most part of unsorted clayey or silty sands and gravels which commonly contain many boulders and cobbles. Till deposits generally average less than 20 feet in thickness and are deeper in the low land areas and thinner towards the top of rock cored hills. Thicker deposits are found in the several drumlins which are found in this area. No distinction is made between the so-called "older" and "younger" tills which have been the subject of much debate. All till in the study area is mapped as one unit.

Glaciofluvial - Glaciolacustrine Deposits

Coarse grained stratified drift deposits are mapped and discussed together. Although the outwash and ice contact deposits may differ significantly in their origins and/or final topographic forms, they are similar in physical characteristics. Most often these deposits consist of sands or sand and gravel with minor amounts of silt and/or clay (less than 10%). They are usually stratified and moderate to well sorted.

Large quantities of these materials are found among deltaic deposits which accumulated in temporary glacial lakes, in outwash plains and as kames deposited on and next to the wasting ice.

The materials mapped and described as lake bottom deposits are limited to those finer grained materials that originally accumulated on the floors of temporary glacial lakes. They are most commonly seen today in valley floors and in level plain-like areas such as near Hanscom Field in Bedford.

The materials referred to as lake bottom deposits are primarily silts and/or sandy silts. Varve clays are reported from the Nashua and Sudbury Valleys, and to lesser extent elsewhere in the area.

Glaciomarine Deposits

Blue-gray silty clays are found along coastal sections of the study area. They are most often described as late-glacial and post-glacial age marine deposits. The occurrence of this clay well above modern sea level elevations indicates landward submergence during the time of its deposition.

Sands and silty sands, often associated with the glaciomarine clays described above, are mapped together with recent dune sands and beach sands. For the most part, the recent beach sands along the Atlantic coast have been derived from glacial materials.

3. Recent Deposits

Marine Organic Deposits

Recent age marine organic silts are found in coastal lowland regions, as for example in the large salt marsh behind Plum Island and the marshes along the North and South Rivers near Duxbury and Scituate. These deposits are commonly related to fluctuations in sea level as were cited above.

Fresh Water Organic Deposits

Fresh water swamp accumulations throughout the area consist of peat and other decomposed organic matter interbedded in places with sands and silts. They are most extensive in valleys and low-lands where they overlie lake bottom deposits, alluvium, or outwash. Elsewhere they occur locally in kettles, or in poorly drained upland rock basins and depressions in the ground moraine. The swamp deposits are generally thin in upland locations, but in several lowland areas are known to exceed fifty feet.

River Terrace and Alluvium Deposits

Much of the material picked up, transported, and deposited by streams in the study area has been derived from glacial deposits. Some of this material was deposited in post-glacial times along river courses that are now abandoned or partially abandoned. River terraces and other features that represent these older stream courses are seen throughout the area. Alluvial material ranging in size from clay through coarse gravel and cobbles is currently being deposited by streams in their channels and along flood plains.

C. Ground Water Geology

1. Supply

Average precipitation in the study area ranges from 42-46" per year, well above the national average of 30". Of the yearly precipitation falling on the area, about 20-22" are evaporated or transpired, leaving 22-24" to recharge the ground water reservoir and provide runoff and base flow for surface streams. Thus, the study area as a whole is provided with an ample supply of both surface and ground water. Water table levels are relatively shallow ranging from 0 to 50-60 feet below the surface depending on local topographic and geologic conditions.

2. Aquifer Descriptions

Ground water in the study area occurs in three different subsurface units: bedrock, glacial till, and stratified unconsolidated deposits. Ground water occurrence depends on porosity (percentage of void space) of the units and movement depends on permeability (relative ease with which the unit can transmit a liquid).

Bedrock

The rocks which underlie the basin are hard and compact. The frequency and distribution of fractures (the only significant source of porosity and permeability in these rocks) are highly variable, but commonly limited to an extent that essentially prohibits any regular large scale withdrawal of ground water.

Glacial Till

The porosity of till deposits may exceed 30 percent, but permeability is low because of the poor sorting and high silt and clay content. These relatively thin deposits provide limited ground water storage potential, and the low lateral permeability results in slow ground water movement. Only limited amounts of water may be withdrawn from till.

Stratified Unconsolidated Deposits

Stratified deposits consisting of very fine sand, silt, and clay have relatively high porosity but low permeability, similar to till. The water table is commonly close to the surface, particularly during the early part of the growing season. Because of these factors, ground water storage potential is limited and lateral water movement is hindered. Fine grained deposits form poor aquifers.

Sand, and sand and gravel stratified deposits have high porosity and relatively high permeability. These deposits commonly occur within the valleys of large streams and their major tributaries. They are also found along abandoned or buried preglacial stream valleys. Some of these deposits form the best aquifers within the area.

IV. SOURCE MATERIAL

A. Bedrock Geology Maps

The available literature concerning the bedrock of eastern Massachusetts dates back to the early nineteenth century. However, the more extensive and exacting mapping of the Massachusetts bedrock really began in the early twentieth century with the publication in 1917 of the Geology of Massachusetts and Rhode Island by B. K. Emerson.

There have been no other studies to date which have mapped the bedrock of the entire study area, although several portions of the area have been investigated and mapped in detail. These other studies, which include U.S. Geological Survey Quadrangle Maps (both published and open file), U. S. Geological Survey Bulletins and Professional Papers, and State reports were used to complement and refine Emerson's work. In addition, several outside sources such as Billings' Geology of New Hampshire, were utilized to provide further data.

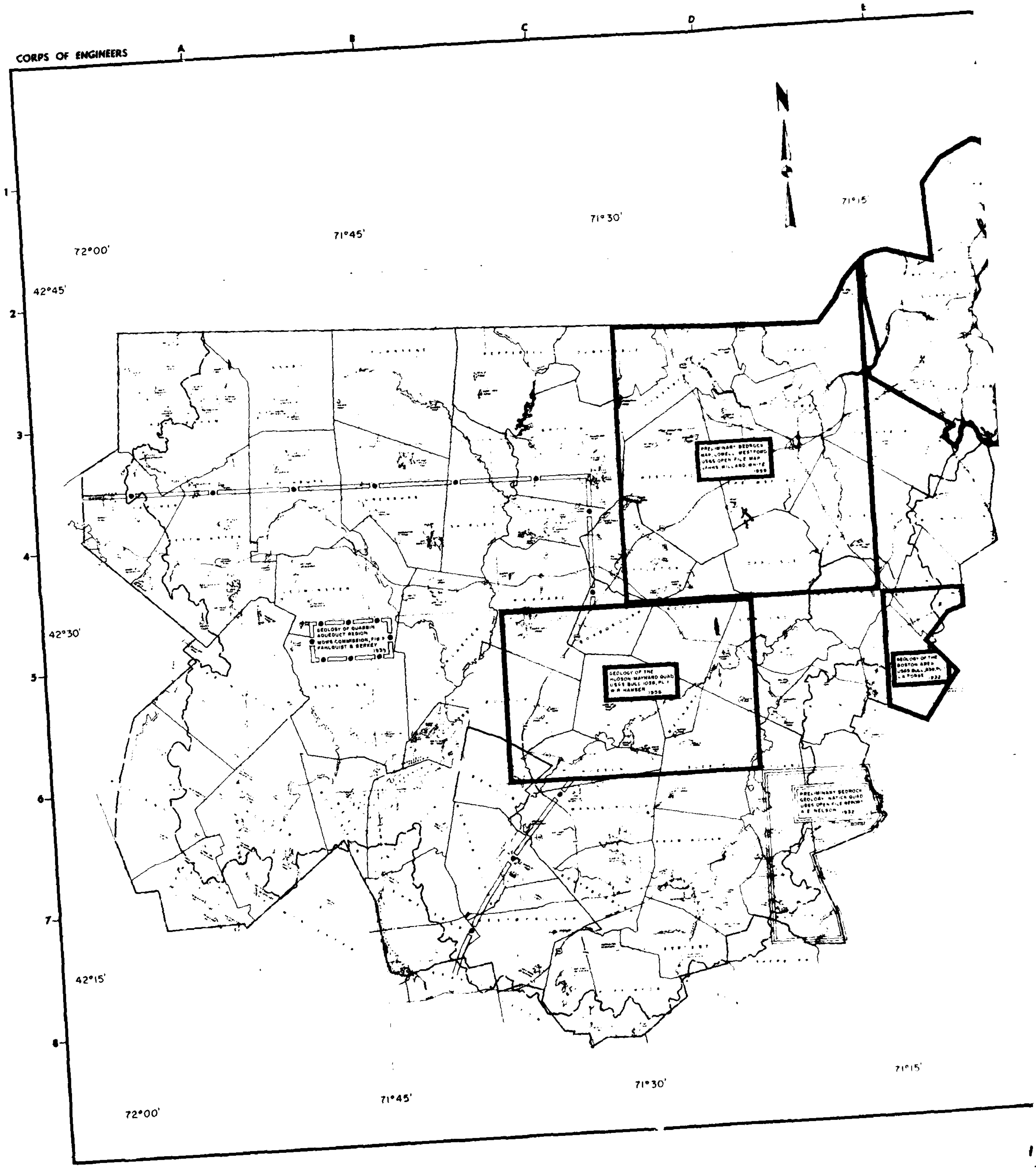
Attempts at coordinating and comparing the works of various authors presented some problems. It quickly became apparent that many of the individual geologists who had worked within the study area differed greatly in their interpretations of the age, sequence, structure, and even composition of the various rock units. For instance, it is not unusual to find two or more names applied to the same rock unit, nor is it a rare occurrence to find that several rock units classified and named by a given author have been lumped together by another writer. As may be seen on the following table , recent studies have identified significant differences in the relationships among the bedrock units. Age and structural relations in the study area are now considered to be quite different from those mapped by earlier workers. A summary of the ages, sequences, and names of the bedrock formations used by various authors for rock units is included in Table 1.

	Diabase Dikes
Hubbardston Gra.	
Fitchburg Gra.	
Dracut Dio.	
Ayer Gra.	
Andover Gra.	Andover Gra
Straw Hollow Dio.	Dracut Dio.
Bolton Gneiss	Beverly Syen.
Brimfield Sch.	
Worcester Phy.	
Boylston Sch.	
Harvard Congl.	Merrimack Qtz
Paxton Qtz. Sch.	
Oakdale Qtz	
Merrimack Qtz.	
Beverly Syen.	
Mattapan Volc.	
Ironstone Qtz. Dio.	Lynn Volcanics
Milford Gra.	
Dedham Granodio	Dedham Granodio
Newburyport Qtz. Dio.	Newburyport Qtz. Dio.
Salem Gabb Dio	Salem Gabb Dio
Newbury Volc	

TABLE 1
AGE. SEQUENCES AND NAMES OF
BEDROCK FORMATIONS
FROM EXISTING LITERATURE

EN & Min- Resources Hudson/ ard Quad Bull. 1038 S) 1956	BILLINGS Geol of NH NH Dept of Resources & Econ. Devol. 1956	JAHNS. WILLARD WHITE. et al Prelim Bedrock Geol. of Lowell-Westford Area USGS open file 1959	TOULMIN Bedrock Geol of Salem Quad Bulletin 1163-A (USGS) 1964	CHUTE Bedrock Geol Blue Hills Quad. USGS GQ-[illegible] 1969	NELSON Prelim Be rock Geol. Map of Nat Quad USGS open file
c Dikes		Diabase Dikes	?Diabase		
n Gra. Gra. w Hollow Dio. bet Qtz. Dio.		Andover Gra. Acton Gra. Ayer Gra. Dracut Norite	Beverly Syenite		
el Hill iss oba FM ester FM udes Brim- d Schist & ard Con- erate	Worcester Phyll. includes Brimfield Schist & Harvard Conglomerate	Nashoba FM		Wamsutta FM Pondville Conglom ?Cambridge Arg	
	?Quincy Gra	Worcester FM includes Brimfield Schist & Harvard Conglomerate		Roxbury Congl	Cambridge Roxbury Co Brighton Metaphyr
ham Granodio Gabb Dio	Andover Gra. Ayer Granodio ?Fitchburg Gra. Dracut Dio. Newbury Volc	?Merrimack Qtz includes "Chelmsford Granite"		?Blue Hills Granite Porphyry ?Quincy Granite ?Mattapan Vol ?Sharon Syen	
	Merrimack Group ?includes Oakdale quartzite & various gneiss & sch		Newbury FM		Mattapan V
			?Newburyport Qtz. Dio	Braintree Arg Cambrian qtzite	Dedham Gra Cherry Bro Kendal Vol Westboro F Rice FM
	Milford Gra. Dedham Granodiorite		Salem Gabb Dio ?Marlboro?FM	?Westwood Gr. ?Dedham Granodiorite ?Salem Gabbrodiorite	

TE rock Geol e Hills d. S GQ-796 1969	NELSON Prelim Bed- rock Geol Map of Natick Quad USGS open file 1973	VOLCKMAN Prelim Bed- rock Geol Map of Holliston Quad USGS open file 1973	BELL et al in USGS/DPW Coop Program Annual Report June 1973
sutta FM dville Conglom bridge Arg			
bury Congl	Cambridge Slate Roxbury Congl Brighton Metaphyre		
e Hills Granite rphyry ncy Granite ttapan Vol aron Syen	Mattapan Volc.	Milford Gra Dedham Granodio	Cape Ann Plutonic Series Beverly Syenite et al
		Marlboro FM	Andover Gra et al
	Dedham Granodio Cherry Brook FM Kendal Volc Westboro FM Rice FM		Nashoba FM Marlboro FM
aintree Arg brian qtzite		Westboro Qtz	Dedham Grano- dio
etwood Gr edham Grano- iorite alem Gabbro- iorite			Marlboro FM (part) Westboro Qtz.



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GEOLOGY OF QUABBIN AQUEDUCT REGION
MDWS COMMISSION, FIG 7
FAHLQUIST & BERKEY
1935
PRELIMINARY BEDROCK MAP, LOWELL WESTFORD
USGS OPEN FILE MAP
JAMES WILLARD WHITE
1959
GEOLOGY OF THE HUDSON-MAYNARD QUAD
USGS BULL 1038, PL 1
W R HANSEN
1956
PRELIMINARY BEDROCK GEOLOGY NATICK QUAD
USGS OPEN FILE REPORT
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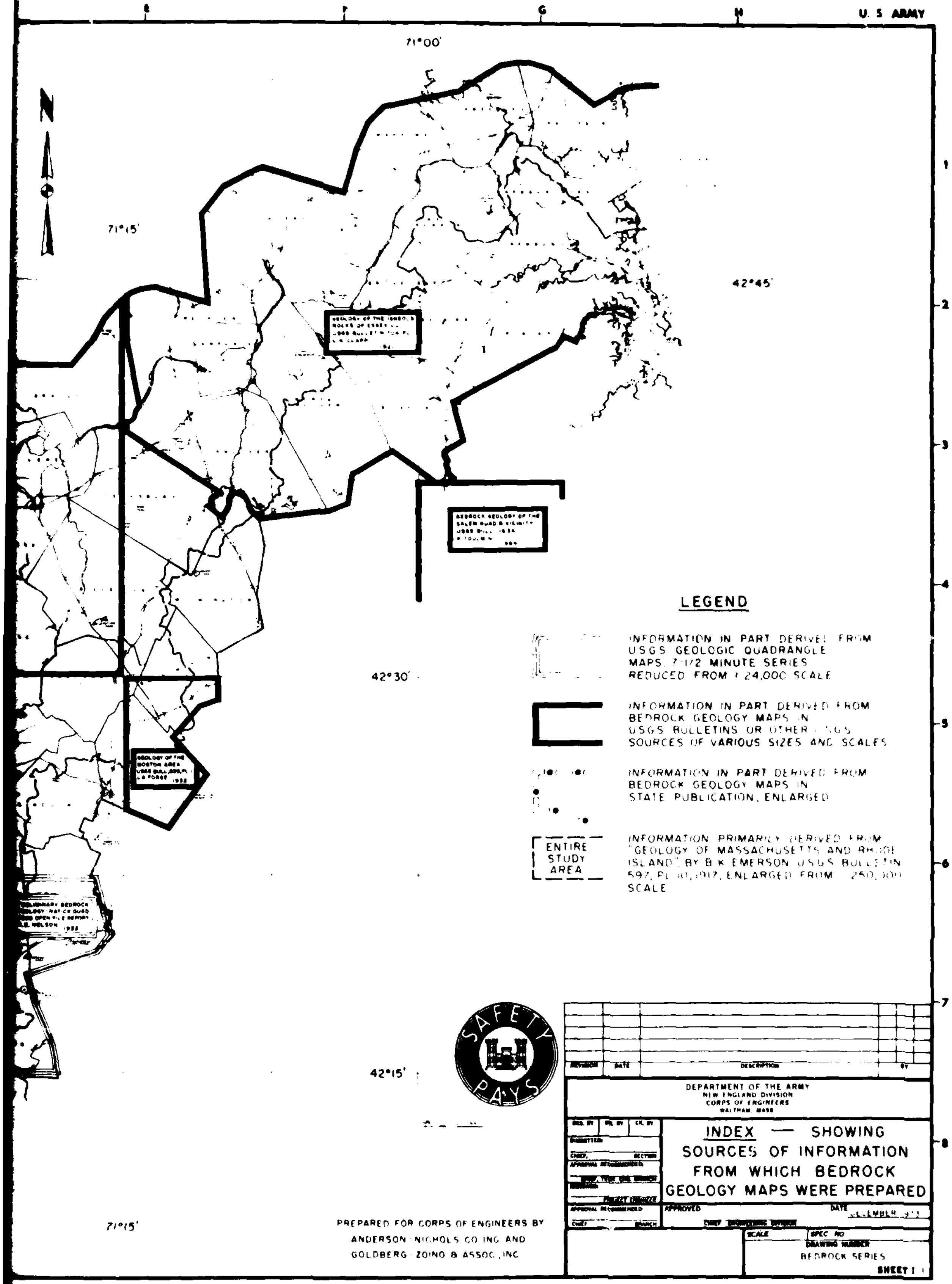
1932



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ENTIRE STUDY AREA
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WALTHAM, MASS
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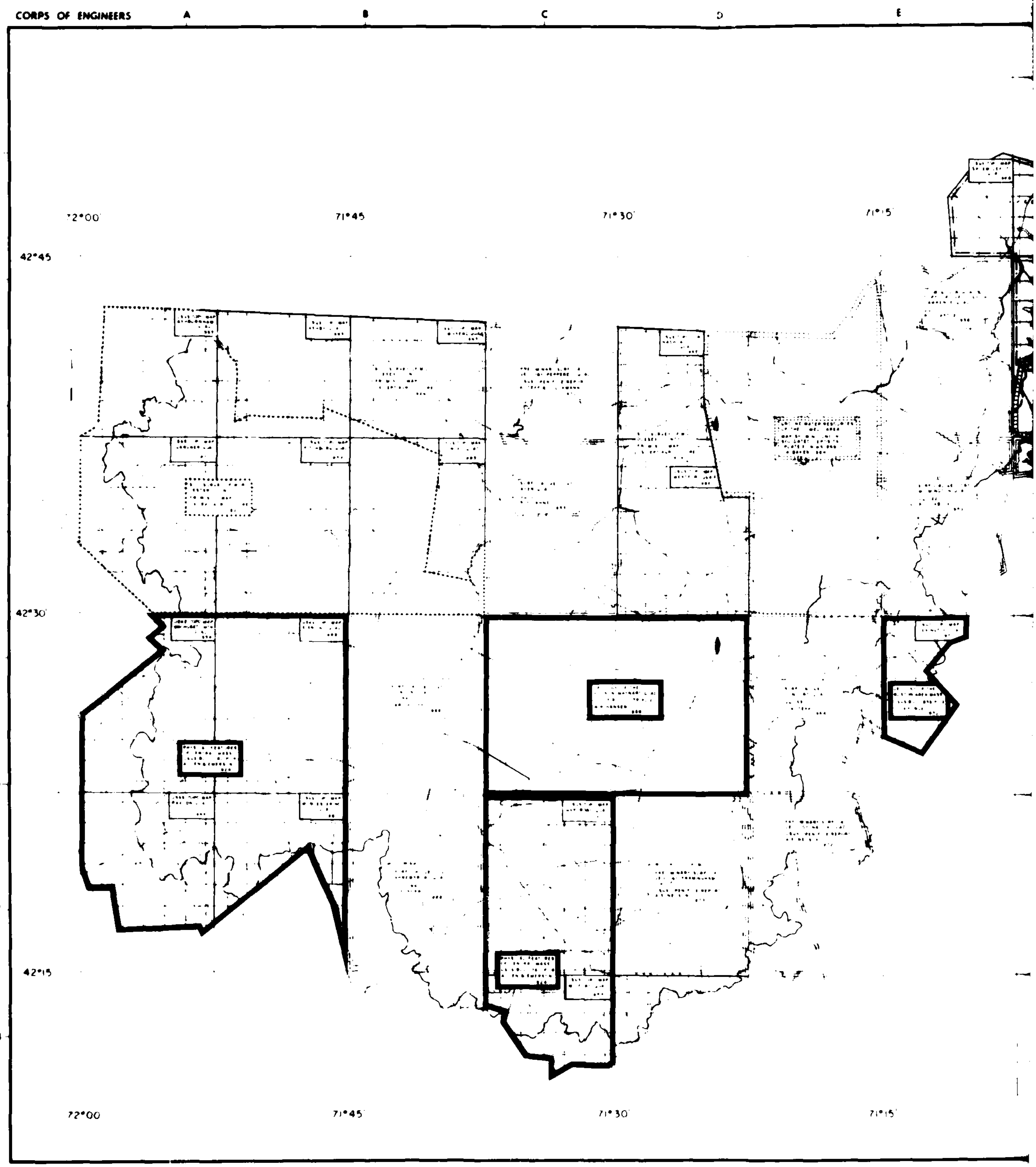

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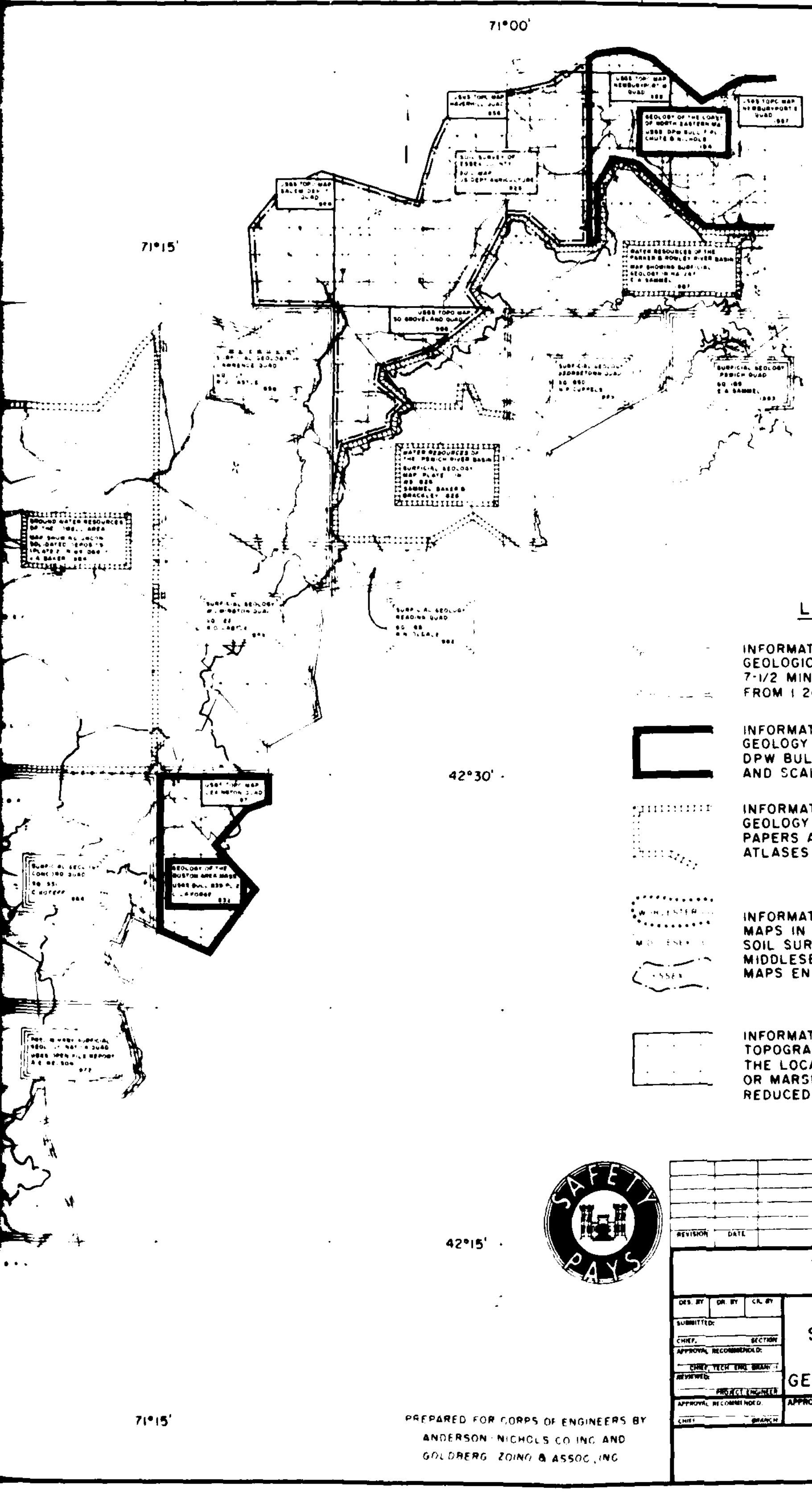

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INFORMATION DERIVED FROM SURFICIAL GEOLOGY MAPS IN U S G S WATER SUPPLY PAPERS AND HYDROLOGIC INVESTIGATIONS ATLASES OF VARIOUS SIZES AND SCALES

INFORMATION DERIVED FROM SOILS MAPS IN US DEPT OF AGRICULTURE SOIL SURVEY PUBLICATIONS (WORCESTER, MIDDLESEX AND ESSEX COUNTIES) MAPS ENLARGED FROM 1:62,500 SCALE

INFORMATION DERIVED FROM U S G S TOPOGRAPHIC MAPS (PRIMARILY USED TO MAP THE LOCATION AND EXTENT OF SWAMPS OR MARSHES), 7-1/2 MINUTE SERIES, REDUCED FROM 1:24,000 SCALE

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WALTHAM, MASS

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REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:
CHIEF, BRANCH
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DATE DECEMBER 1973
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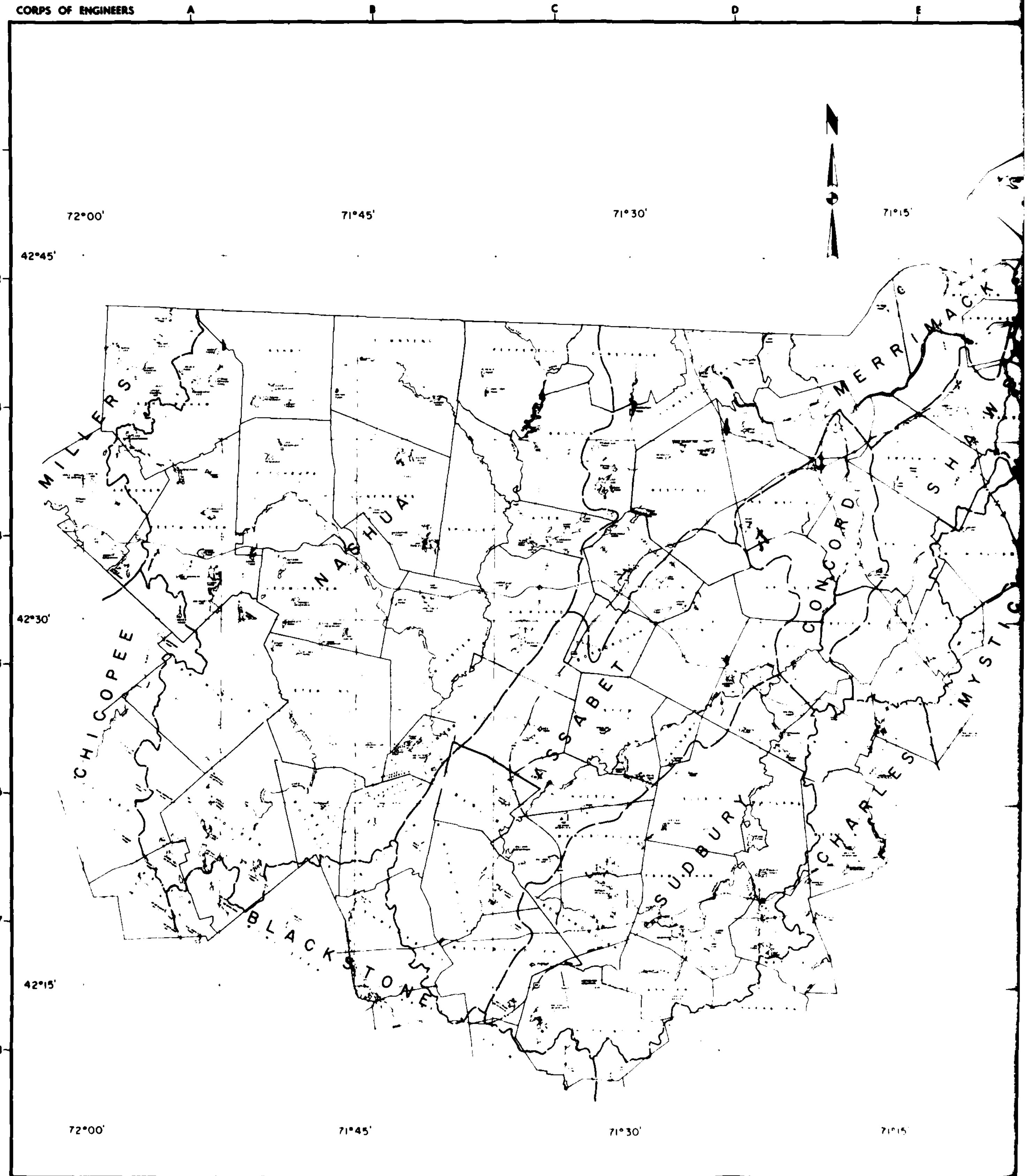
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MERRIMACK
SHAWSHEEN
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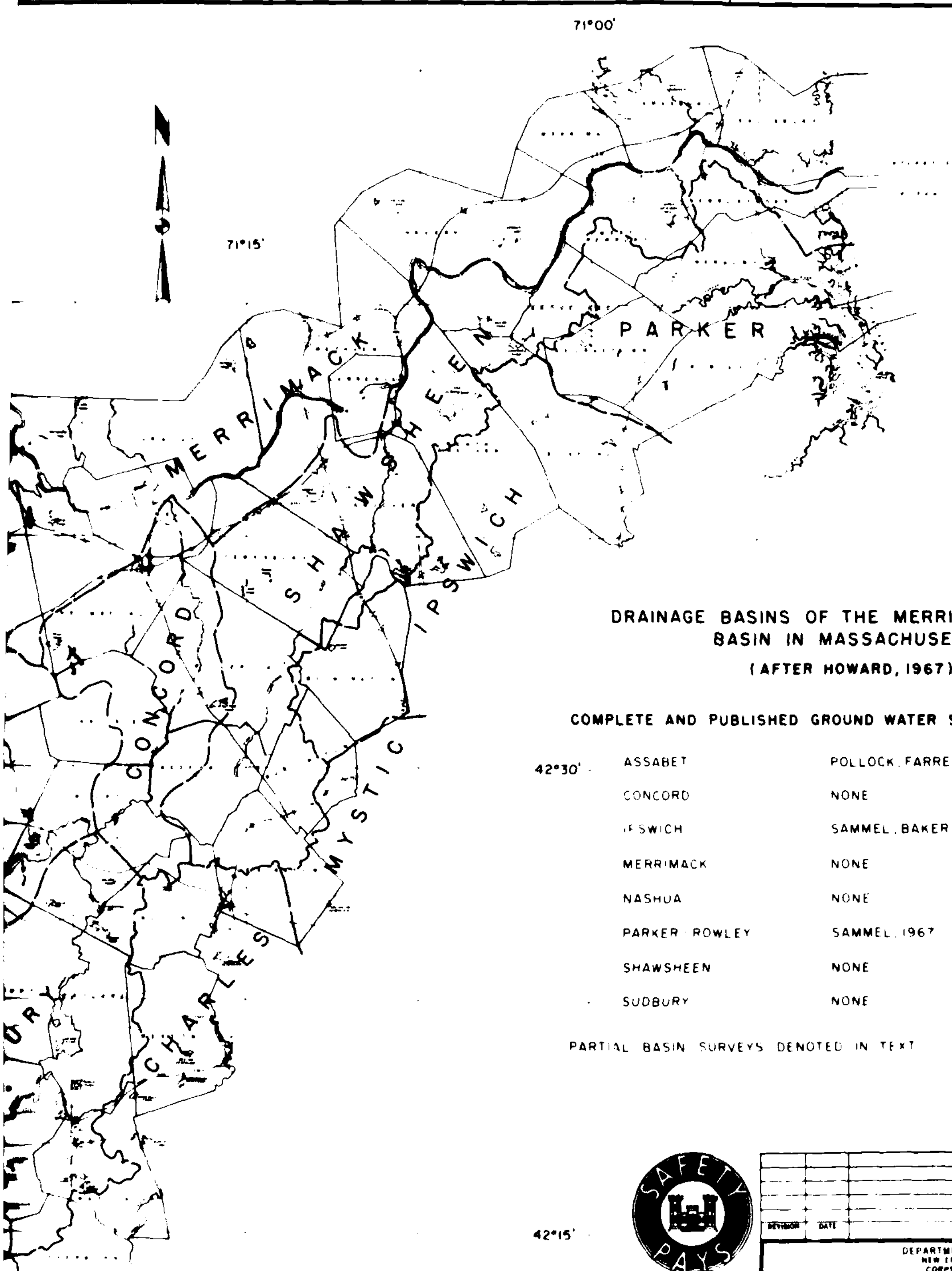
MYSTIC
CHICOPEE
ASSABET
SUDBURY
CHARLES
BLACKSTONE



DRAINAGE BASINS OF THE MERRIMACK RIVER BASIN IN MASSACHUSETTS

(AFTER HOWARD, 1967)

COMPLETE AND PUBLISHED GROUND WATER SURVEYS:

ASSABET	POLLOCK, FARRELL, AND CASWELL 1969
CONCORD	NONE
IPSWICH	SAMMEL, BAKER, AND BRACKLEY, 1966
MERRIMACK	NONE
NASHUA	NONE
PARKER - ROWLEY	SAMMEL, 1967
SHAWSHEEN	NONE
SUDBURY	NONE

PARTIAL BASIN SURVEYS DENOTED IN TEXT

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DRAINAGE BASINS OF THE
MERRIMACK RIVER BASIN
(AFTER HOWARD, 1967)

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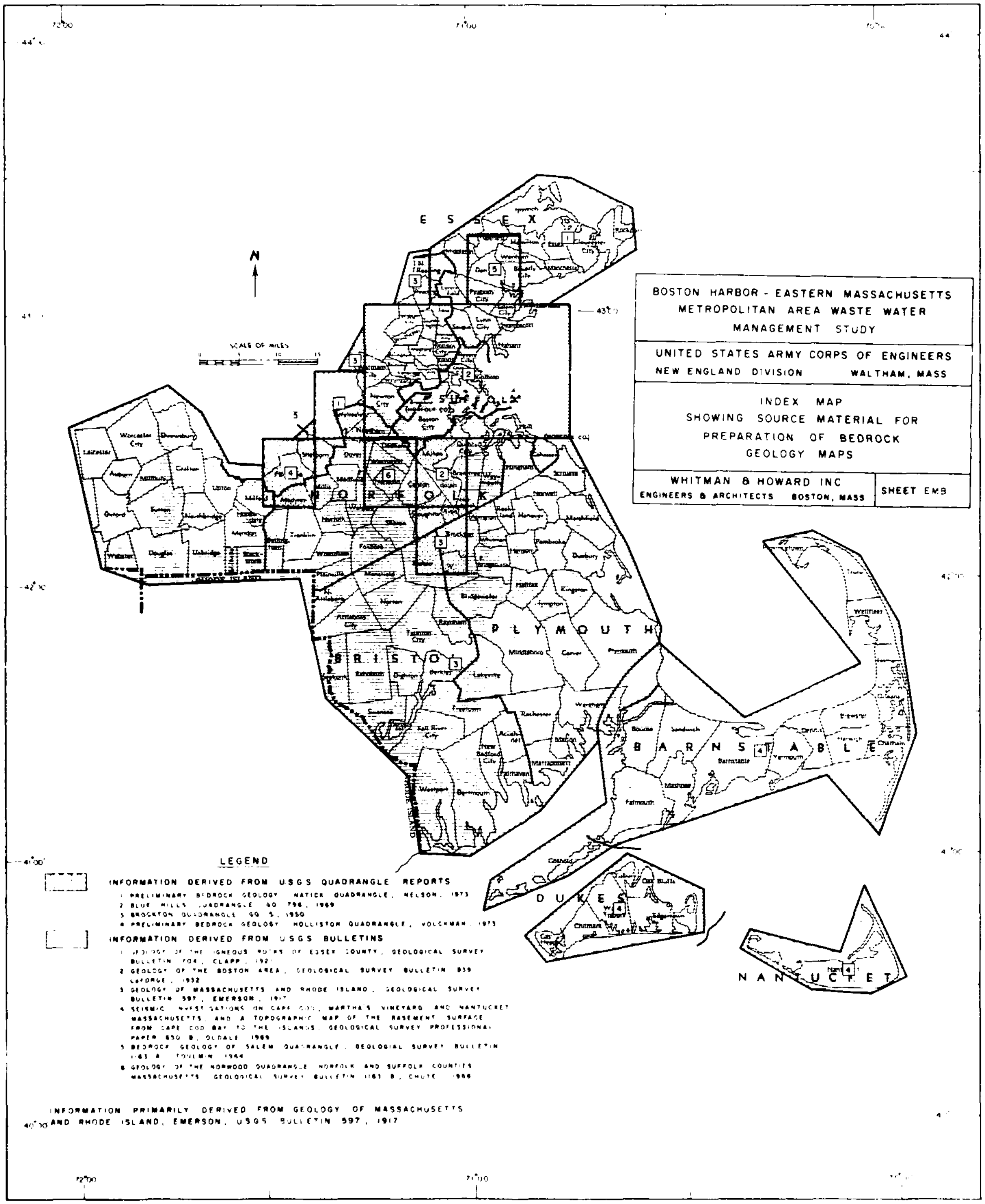
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METROPOLITAN AREA WASTE WATER
MANAGEMENT STUDY
UNITED STATES ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION WALTHAM, MASS
INDEX MAP
SHOWING SOURCE MATERIAL FOR
PREPARATION OF BEDROCK
GEOLOGY MAPS
WHITMAN & HOWARD INC
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2 BLUE HILLS QUADRANGLE GQ 796, 1969
3 BROCKTON QUADRANGLE GQ 5, 1950
4 PRELIMINARY BEDROCK GEOLOGY HOLLISTON QUADRANGLE, VOLCKMAN, 1973
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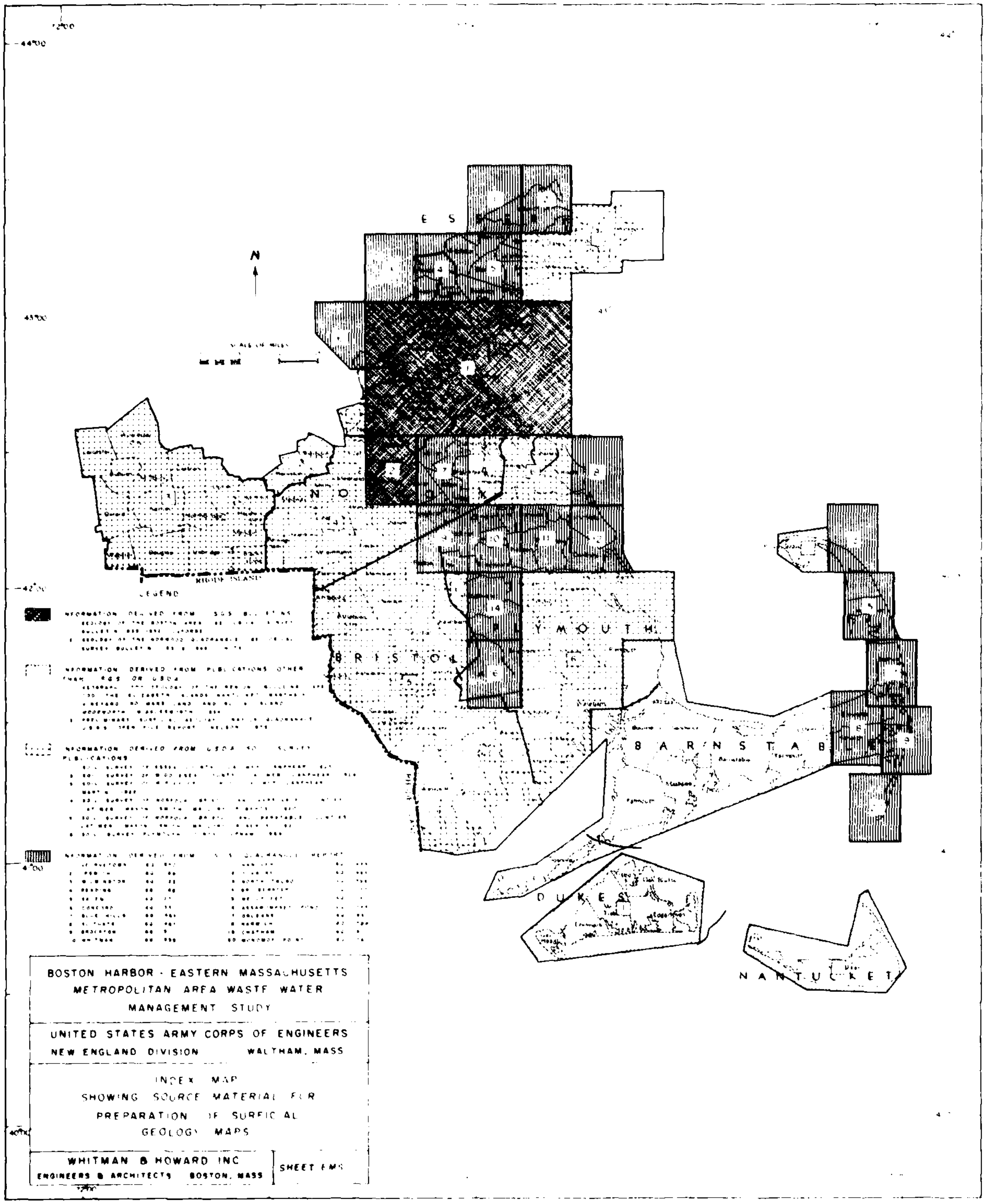
1 GEOLOGY OF THE IGNEOUS ROCKS OF ESSEX COUNTY, GEOLOGICAL SURVEY BULLETIN 704, CLAPP, 1921
2 GEOLOGY OF THE BOSTON AREA, GEOLOGICAL SURVEY BULLETIN 839 LaFORGE, 1932
3 GEOLOGY OF MASSACHUSETTS AND RHODE ISLAND, GEOLOGICAL SURVEY BULLETIN 597, EMERSON, 1917
4 SEISMIC INVESTIGATIONS ON CAPE COD, MARTHA'S VINEYARD AND NANTUCKET MASSACHUSETTS, AND A TOPOGRAPHIC MAP OF THE BASEMENT SURFACE FROM CAPE COD BAY TO THE ISLANDS, GEOLOGICAL SURVEY PROFESSIONAL PAPER 650 B, OLDALE 1969
5 BEDROCK GEOLOGY OF SALEM QUADRANGLE, GEOLOGIAL SURVEY BULLETIN 1163 A TOULMIN 1964
6 GEOLOGY OF THE NORWOOD QUADRANGLE NORFOLK AND SUFFOLK COUNTIES MASSACHUSETTS GEOLOGICAL SURVEY BULLETIN 1163 B, CHUTE 1966
INFORMATION PRIMARILY DERIVED FROM GEOLOGY OF MASSACHUSETTS AND RHODE ISLAND, EMERSON, USGS BULLETIN 597, 1917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NEW ENGLAND DIVISION WALTHAM, MASS
INDEX MAP
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GEOLOGY MAPS
WHITMAN & HOWARD INC
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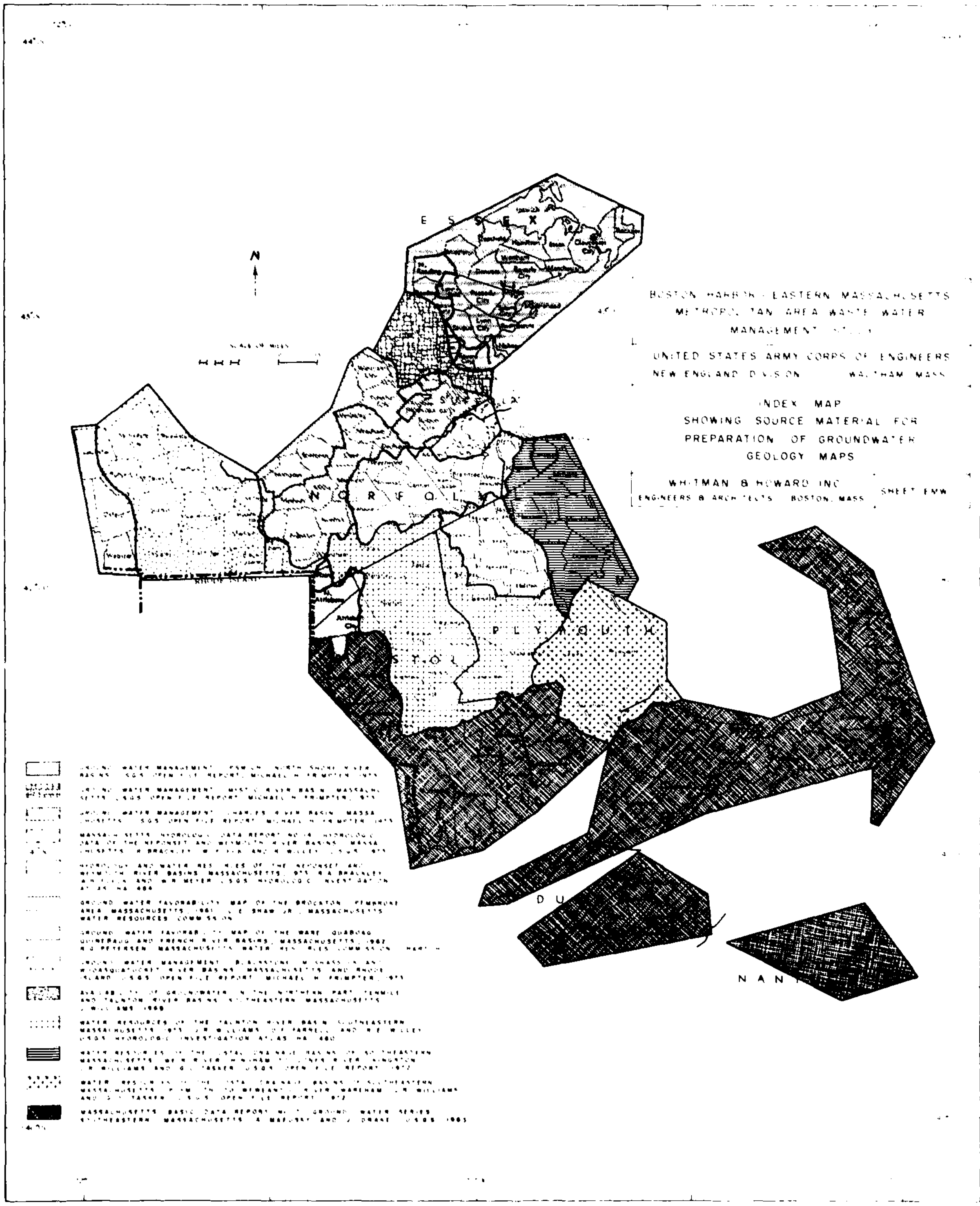
BOSTON HARBOR - EASTERN MASSACHUSETTS
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B. Surficial Geology Maps

The sources of available information from which the surficial geology maps were prepared include: U.S. Geological Survey Quadrangle Maps (GQ Series); Surficial Geology Maps in U.S. Geological Survey and Massachusetts DPW Bulletins; Surficial Geology Maps and "materials" maps in U.S. Geological Survey Water Supply Papers; Soil Maps in U.S. Department of Agriculture Publications and U.S. Geological Survey Topographic Maps (7-1/2 Minute quadrangles). Where applicable, information derived from studies other than described above were incorporated. These included open file reports and The Geography and Geology of the Region Including Cape Cod, the Elizabeth Islands, Nantucket, Martha's Vineyard, No Man's Land, and Block Island by J.B. Woodworth and E. Wigglesworth.

When available, the maps of the U.S.G.S. Bulletins, Quadrangle Reports and Open File Reports were regarded as the most accurate description of the surficial deposits and were, therefore, used without alteration. The maps contained in the Woodworth and Wigglesworth publication were used to describe those areas of the Cape and the Islands where no U.S.G.S. maps were available. Lastly, where no other source of information was available, the soils of Eastern Massachusetts were grouped together into categories determined by the type of surficial sediment which they most likely overlie. Then, using the various county soils maps and U.S.G.S. topographic maps (for swamp and marsh determination) the surficial deposits were plotted on the base map.

C. Ground Water Geology Maps

Sources of information used in compiling the ground water geology maps of the study area consisted of maps and descriptive material included in: (a) ground water favorability studies by the U.S. Geological Survey and the Massachusetts Water Resources Commission; (b) U.S. Geological Survey Hydrologic Investigations Atlases; and (c) U.S. Geological Survey Open File Reports. Ground water data on file at the Ground Water Branch of the U.S. Geological Survey in Boston, Massachusetts and included in Massachusetts Basic Data Reports was also used.

D. Index Maps

Listings of the specific maps and other source materials used for the various subdivision of the study area are given on the index maps immediately following this section of the report. Sheets I-1, I-2 and I-3 show the bedrock, surficial and ground water source material used to compile the Merrimack Basin part of the study and sheets EMB, EMS, and EMW list the respective source materials used in the Eastern Massachusetts portion of the study.

V. EXPLANATION OF LEGEND AND MAPPING PROCEDURES

A. Bedrock

Considering all the available information, a partial map illustrating the distribution and extent of rock units mapped by modern workers could be prepared. Or, on the other hand, a complete map showing the location and occurrence of rock units for the entire study area could be taken from the early study by Emerson in 1917. It would be impossible to completely reconcile the two contrasting series of data and yet maintain the meaning and intent of either. We have chosen the latter course of action, that being to use Emerson's work as the basis for our mapping. His bedrock units within the study area have been divided into two groups: (1) Igneous Rocks, and (2) Sedimentary and Meta-Sedimentary Rocks. Within these groups, Emerson's descriptions and names have been used for the various rock units he identified and mapped. More recent information has been added to the maps whenever it was sufficiently extensive so as to provide continuity among the mapped units. These data include new names applied to some of Emerson's unnamed formations, additional rock units identified by modern workers in certain areas, and regrouped or "lumped" rock units that today are thought to be similar in composition, age and structural relationships.

The bedrock beneath the area southeast of a line roughly parallel to, and approximately 15 miles northwest of, the Cape Cod Canal including the Cape itself, Martha's Vineyard, Nantucket and the smaller islands of Nantucket Sound is overlain by such thick surficial deposits that few wells have encountered bedrock. For this reason, little is known about the nature of the underlying rock. Where wells have penetrated the overlying cover and have reached bedrock, they have been plotted and the depth to bedrock (in feet below sea level) has been recorded. Interpretation of the cuttings has been recorded on the map for those wells for which there was available data. Otherwise, this area, which appears on sheet EMB-3 has been shown with contour lines indicating depth to bedrock in feet below sea level. These contours were largely taken from the seismic study of Cape Cod and the Islands published by R.N. Oldale in 1969. They have, however, been re-drawn where shown to be inaccurate near the presently existing well sites.

B. Surficial Geology

The several source materials used in the preparation of the surficial maps varied both in the manner and the intent for which they were written. In some of the sources, the deposits were classified on lithology alone, in others the classification tended to be based on morphological characteristics (e.g. kame terraces and outwash plains) and in still others the classification was more genetic such as various lake stages or formational units. For purposes of this report, a classification system was developed which could incorporate and be compatible with all of the available data.

The surficial deposits of the area were divided into two primary groups: (a) coarse grained sediments and (b) fine grained and/or organic sediments. This distinction, while primarily based on grain size, also incorporates such closely-related properties as dry unit weight, water content, plasticity, porosity and consolidation. Each of the two primary groups was then subdivided into four categories on the basis of origin. Table 2 lists the various deposit classifications, the map symbols assigned for each, some comments regarding the origin and lithologic materials description of each category, and a list of representative land forms exhibited by each of the deposits.

Some of the deposits in the eastern Massachusetts area are quite small in areal size and thus are difficult to recognize on the maps of that part of the study area. For this reason they are assigned letter as well as pictorial symbols. The scale used in the eastern Massachusetts part of the study also required that the fine grained and/or organic soils be subdivided into two categories rather than the four categories used in the Merrimack study. Areas shown on the maps of the eastern Massachusetts portion of the study area by crosshatching represent glaciolacustrine and glaciomarine fine grained sediments. The former, consisting chiefly of glacial lake bottom sediments, are further designated by the letter Qlf and the latter, designated by Qmf, are the fine grained marine deposits of the once offshore marine terraces and plains.

The solid black symbol represents the organic deposits with the salt water organics distinguished from the freshwater organics by the symbols Qom and Qof respectively. Since most of the organic deposits were of freshwater origin, only those areas where there may be doubt were given the aforementioned distinguishing letter symbols, otherwise any solid black area is to be considered as a freshwater organic deposit. Generally, the freshwater deposits are found in old lake basins, cutoff river meanders, kettle holes or dammed off glacial valleys, whereas the marine organics are found near river mouths, along estuaries and in tidal flats and marshes.

One other type of deposit occurs only within the metropolitan Boston area of sheet EMS-1 in large enough extent to be mapped. This is the artificial fill that has built up over the past three hundred years, and upon which much of Boston, Cambridge, and Chelsea is built. This artificial fill is represented by the "patchwork quilting" type symbol directly below the standard Legend on Map EMS-1.

Table 3 describes the engineering characteristics of the aforementioned eight types of surficial sediments. The information shown here was taken from the Engineering Geology of the Northeast Corridor, Washington, D.C., to Boston, Massachusetts, Coastal Plain and Surficial Geology, 1967, U.S.G.S. Miscellaneous Geologic Investigations Map I-514-B, Sheet 7.

C. Ground Water Geology

Due to marked differences in availability and content of source material, the Merrimack and eastern Massachusetts portions of the study area were treated differently with respect to evaluation of ground water favorability. Index maps I-3 and EMW list the source materials and well illustrate the contrast between the abundance of data available for the eastern Massachusetts report and the relatively small amount of material which has been completed in the Merrimack Basin. One further point which will help in the interpretation of the ground water favorability categories formulated for both parts of the study area is the fact that much of the analysis in the Merrimack area was based on data gathered from private small yield wells while yields from municipal and other large wells made up a large part of the data used to draw up favorability maps for the eastern Massachusetts area.

Merrimack Basin

With the exception of a ground water favorability map of the Assabet Basin, little comprehensive data regarding ground water occurrence in the Merrimack River Basin in Massachusetts has been compiled and published. It was necessary, therefore, to employ the closely corresponding relationship between the surficial and ground water geology characteristics evidenced in areas which had been mapped for both and then extrapolate that relationship in other parts of the basin for which only the surficial geology is mapped. Complemented by some local data and some ground water geology maps of adjoining basins, the extrapolation was used as the means to formulate ground water favorability maps of the Merrimack Basin. The patterns shown on the maps must be considered reconnaissance estimates everywhere except in the Assabet basin.

The same ground water favorability categories used by the U.S. Geological Survey in their study of the Assabet Basin were also used in this study of the entire Massachusetts portion of the Merrimack Basin. These categories are:

a. Areas where most wells will yield less than 25 gallons per minute. The aquifer consists of poorly permeable material, chiefly till and bedrock, but also includes some areas of sand and gravel, the saturated thickness of which is generally less than 25 feet. This category is unfavorable for the development of ground water supplies. The unfavorable areas are shown in sheet W as having no pattern other than surficial geology pattern.

b. Areas where yields from properly constructed wells may range from 25 to 75 gallons per minute (also includes some areas whose ground water potential is unknown). In these areas the aquifers consists of sand and gravel, the saturated thickness of which generally is greater than 25 feet. This category is favorable for development of moderate ground water supplies. These areas are shown as a pattern of closely-spaced stippling over the surficial geological map units.

TABLE 2

SUMMARY OF MATERIALS USED
on
S U R F I C I A L G E O L O G Y M A P S

	SYMBOL used on PLANS	DEPOSITS	ORIGIN (Transportational and/or Depositional Agent)	REPRESENTATIVE LAND FORMS	MATERIAL DESCRIPTION
Coarse-Grained Soils	Qsc	Glacio-fluvial Glacio-lacustrine (stratified drift; outwash and ice contact)	via Glacial streams	Outwash Plains, Kame Terraces, Kames, Eskers, Crevasse Fillings; Kame deltas, Esker deltas	SANDS or SANDS & GRAVELS; Silt and/or Clay portions usually minor - may include cobbles--stratified, moderate to well sorted.
	Qmc	Glacio-marine Dune deposits	Reworked glacial & stream deposits-via tidal action, currents; wind blown	Marine terraces, Marine plains, Dunes, Beaches, Bars	Primarily fine or fine to medium SANDS well sorted - often stratified and cross-bedded.
	Qac	Alluvium & River Terrace deposits	via Recent rivers and streams	Flood plains, Alluvial terraces, Alluvial flats, Alluvial fans, stream terraces	SAND, SILT, with minor amounts of Gravel and/or Clay - poorly to moderately sorted and stratified.
	Qtc	Glacial Till (non-stratified drift deposits)	Subglacial, Superglacial (Lodgement & Ablation), Flow till	Ground Moraine, End Moraine, Drumlins, Slumped/Flow structures	Silty or Clayey SANDS & GRAVELS with cobbles and boulders - generally dense, non-stratified, unsorted mixture; locally variable.
Fine-Grained and/or Organic Soils	Qlf	Glacio lacustrine (stratified drift)	via Glacial streams into glacial lake bottoms	Lake basins, Lake beds	SILTS, Clayey SILTS, Silty SANDS, varved Silts and Clays
	Qmf	Glacio-Marine	via Glacial streams into offshore marine environment	Marine plains, marine terraces	Silty CLAYS, SILTS and CLAYS, SILTS, Silty fine SANDS.
	Qo	Fresh water Organic deposits	Eutrophication of ponds, lakes, etc	Kettle holes, morainal depressions, lake basins, river meanders	PEATS, Sandy PEATS, Silty PEATS, Organic Sands or Silts, "Muck"
	Qom	Marine Organic deposits	Accumulation of organic detritus associated with the flooding of coastal plains	Estuaries, tidal marsh and mud flats; river mouths	ORGANIC SILTS, Clayey Organic Silts, Organic Sands, Marsh Mats, "Muck"

TABLE 3 ENGINEERING CHARACTERISTICS OF SURFICIAL DEPOSITS

Map Unit	Foundation Conditions[1]	Excavation Characteristics	Slope Stability[2]
Qsc	Bearing capacity of sand and gravel fair to good; of silt and clay, less. Local artesian water pressure reduces bearing values. Vibratory loading on sand may cause settlement.	Easy to excavate by power equipment; in valleys of tidal rivers may be excavated by dredge.	Excavations below water table require support.
Qmc	Bearing capacity poor to fair; improved by vibration.	Easy to excavate with power equipment. Beach sand to dredge.	Cut slopes stable to angle of repose; steeper slopes need lagging because sand is free running when dry; readily flows into excavations below water table.
Qal	Bearing capacity poor to fair in sandy alluvium; very poor to poor on silt, clay. Structures founded over small lenses of compressible clay or silt settle unevenly. Water table shallow. Compressibility and expansion negligible except in thick organic deposits.	Easy to excavate by power equipment; in rivers may by excavated by dredge.	Excavations below water table require support.
Qtc	Bearing capacity generally good because of high density and poor sorting. Expansion negligible.	Generally easy to moderately difficult to excavate with power equipment. Highly compacted till ("hardpan"), and very strong and bouldery till can be troublesome to excavate without special equipment.	Cuts higher than 40 ft. generally require individual stability analysis. For lower slopes, 1 1/2 on 1 to 2 on 1 generally considered safe. Vertical slopes up to 15 ft. common, particularly in more cohesive clayey till.

Map Unit	Foundation Conditions[1]	Excavation Characteristics	Slope Stability[2]
Qlf, Qmf	Bearing capacity generally poor. Where oxidized and preconsolidated, capacity fair. When confined and loaded, pore-water pressure increases and shearing strength decreases. Where saturated, dewatering may cause consolidation over large area. Compressibility high to low; expansion negligible to moderate.	Easy to excavate; wet conditions hamper construction equipment. "Quick" reaction to vibration in silt.	Generally unstable except in shallow dewatered cuts with gentle slopes. Support usually required. Clay is somewhat fissured and may fail along vertical joints. Sensitivity low.
Qof, Qom	Bearing capacity very poor. Compressibility high.	Easy to excavate by dredge or dragline.	Unstable; flows readily into underwater excavations.

[1]Bearing capacity - numerical values (tons per square foot) applied to qualifying adjectives:

Very poor	less than 1
Poor	1-4
Fair	4-8
Good	8-32
Excellent	greater than 32

[2]Cut slopes - numerical values, in degress, applied to qualifying adjectives:

Vertical	90
Near vertical	80-89
Steep	45-80
Moderate	30-45
Gentle	0-30

Compressibility - volume decrease in a soil mass in response to an external load.
Expansion - volume increase that is a function of load, time, density, water content, and type of clay minerals.

c. Areas most favorable for the location of wells that may yield more than 75 gallons per minute. This unit generally consists of sand and gravel, the saturated thickness of which is greater than 25 feet. Although yields from wells in these areas may, in places, range as high as 500 gallons per minute, the most common safe yield from properly constructed wells is probably in the 100 to 150 gallons per minute range. This category is favorable for development of moderate to large volumes of ground water. These areas, which are shown in sheet W by the large dot stipplings, are considered the least completely mapped outside the Assabet, particularly along river channels and in towns where water supply data is not readily available.

Eastern Massachusetts

The legend produced for this study of the favorability of ground water is based on U.S.G.S. mapping legends which describe the aquifers and the potential ground water yields that can be expected from those aquifers in this area. This study defines three categories of aquifers and the expected yields to be obtained from them. The three categories are:

a. Favorable for development of moderate to large volumes of ground water; saturated thickness generally larger than 40 feet; generally capable of yielding more than 300 gpm.

b. Favorable for development of low to moderate volumes of ground water; saturated thickness generally from 20 to 40 feet; generally capable of yields from 100 to 300 gpm.

c. Favorable for development of low volumes of ground water; saturated thickness generally less than 20 feet; generally capable of yields from 0 to 100 gpm with the lowest yields in till.

This legend should be interpreted as a qualitative description of ground water favorabilities. Not all the areas have quantitative data in the form of actual well yields.

VI. CONCLUSIONS

A report of the geology of eastern Massachusetts was compiled from existing literature. This study is a summary of two more detailed studies which deal with: (a) the geology of the Massachusetts portion of the Merrimack Basin and (b) the geology of Massachusetts east of longitude 71°, 52', 30" W, excluding the Merrimack Basin. These reports are on file at the U.S. Army Corps of Engineers, NED, Waltham, Massachusetts.

The bedrock, surficial and ground water geology of the study area is discussed along with the source material from which this information was derived. Maps illustrating the bedrock, surficial and ground water geology for the Merrimack and eastern Massachusetts portions of the study were prepared and printed with this report.

Index maps showing the various specific references used for various locations within the study area are included in this summary along with a selected bibliography listing published and unpublished source material.

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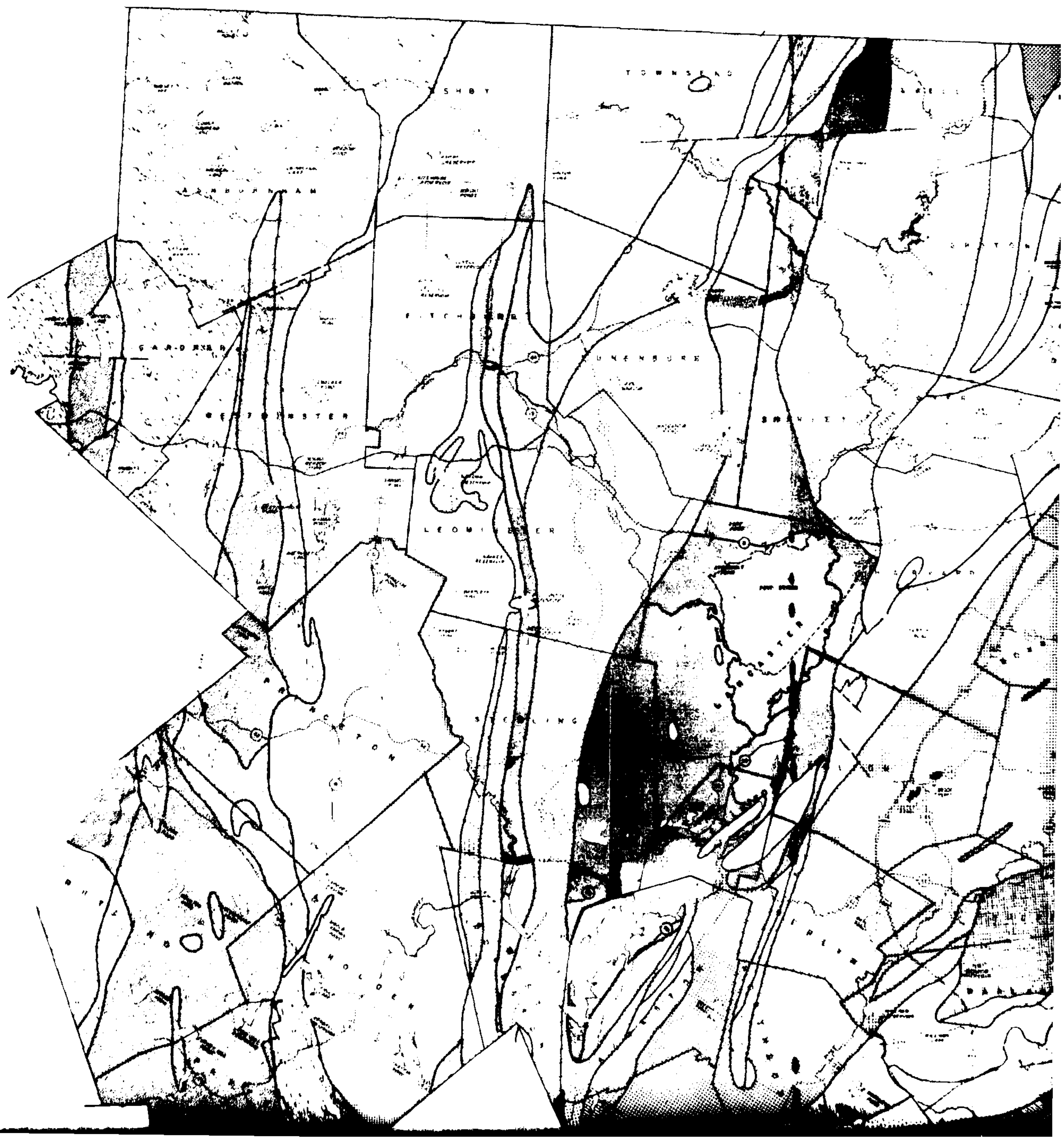
Appendix

GEOLOGIC MAPS OF

EASTERN MASSACHUSETTS

A SUMMARY OF THE AVAILABLE INFORMATION
SHOWING THE DISTRIBUTION OF BEDROCK UNIT
IN THE MERRIMACK RIVER BASIN (MASSACHUSETTS



NFORMATION
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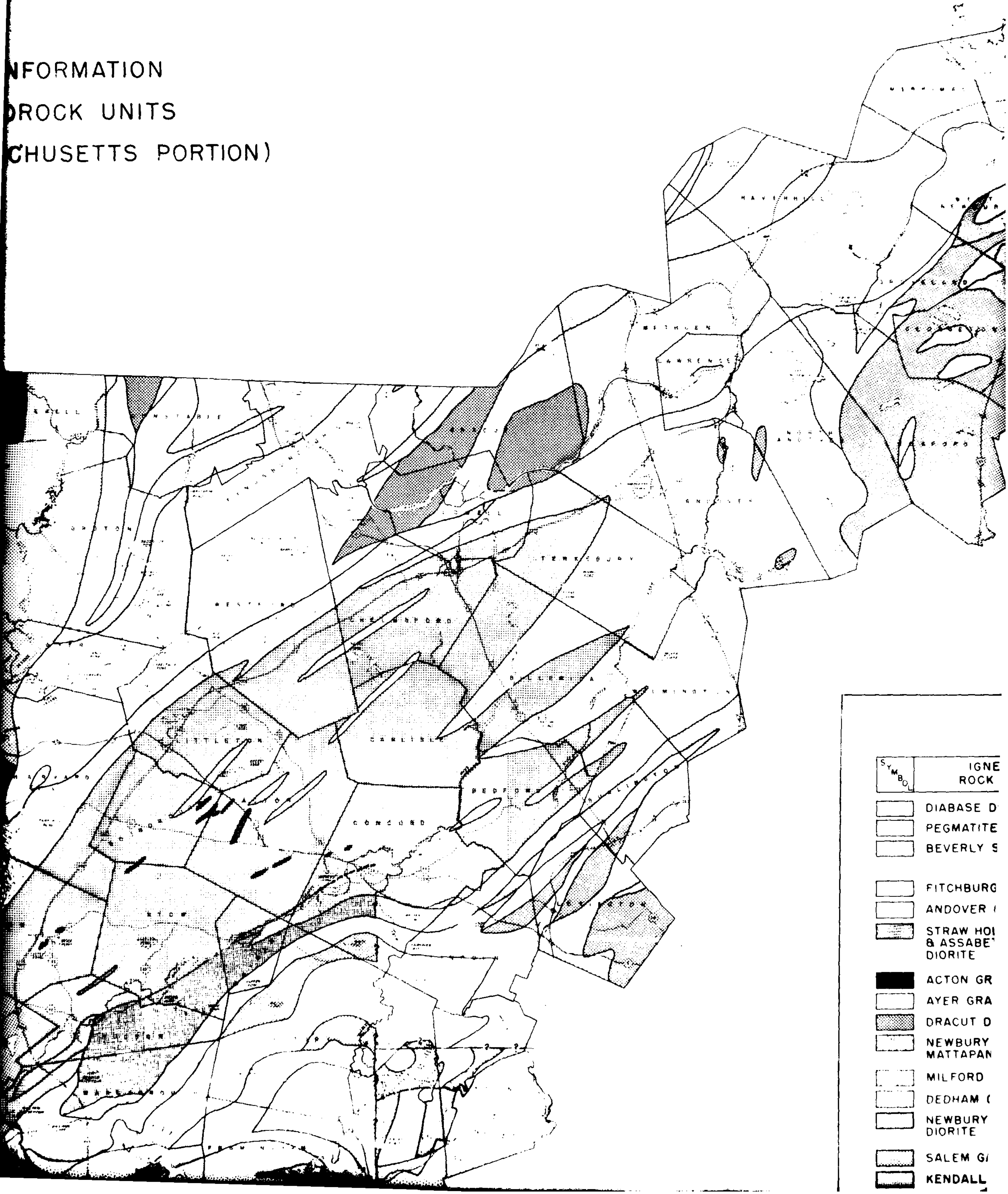

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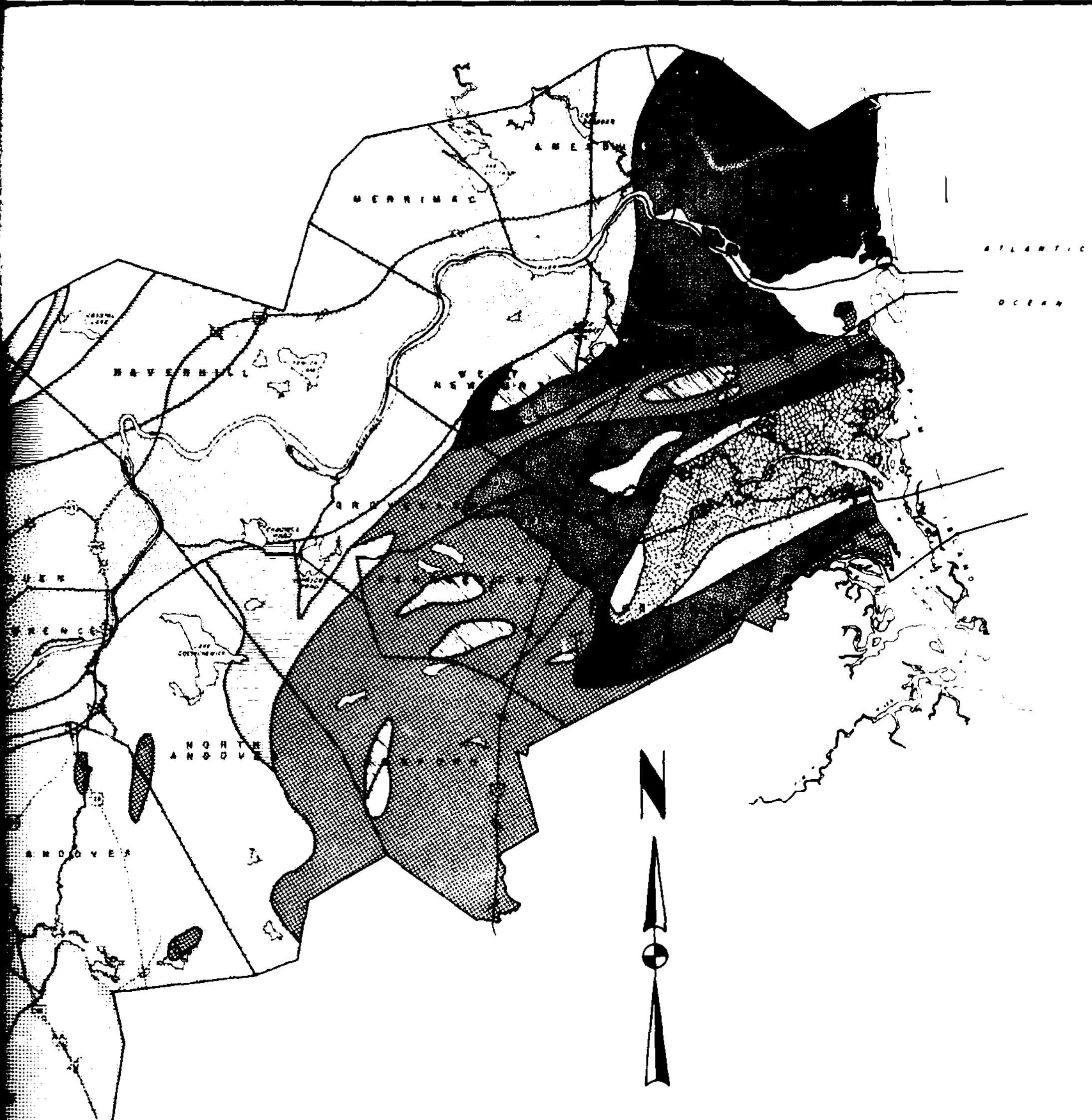
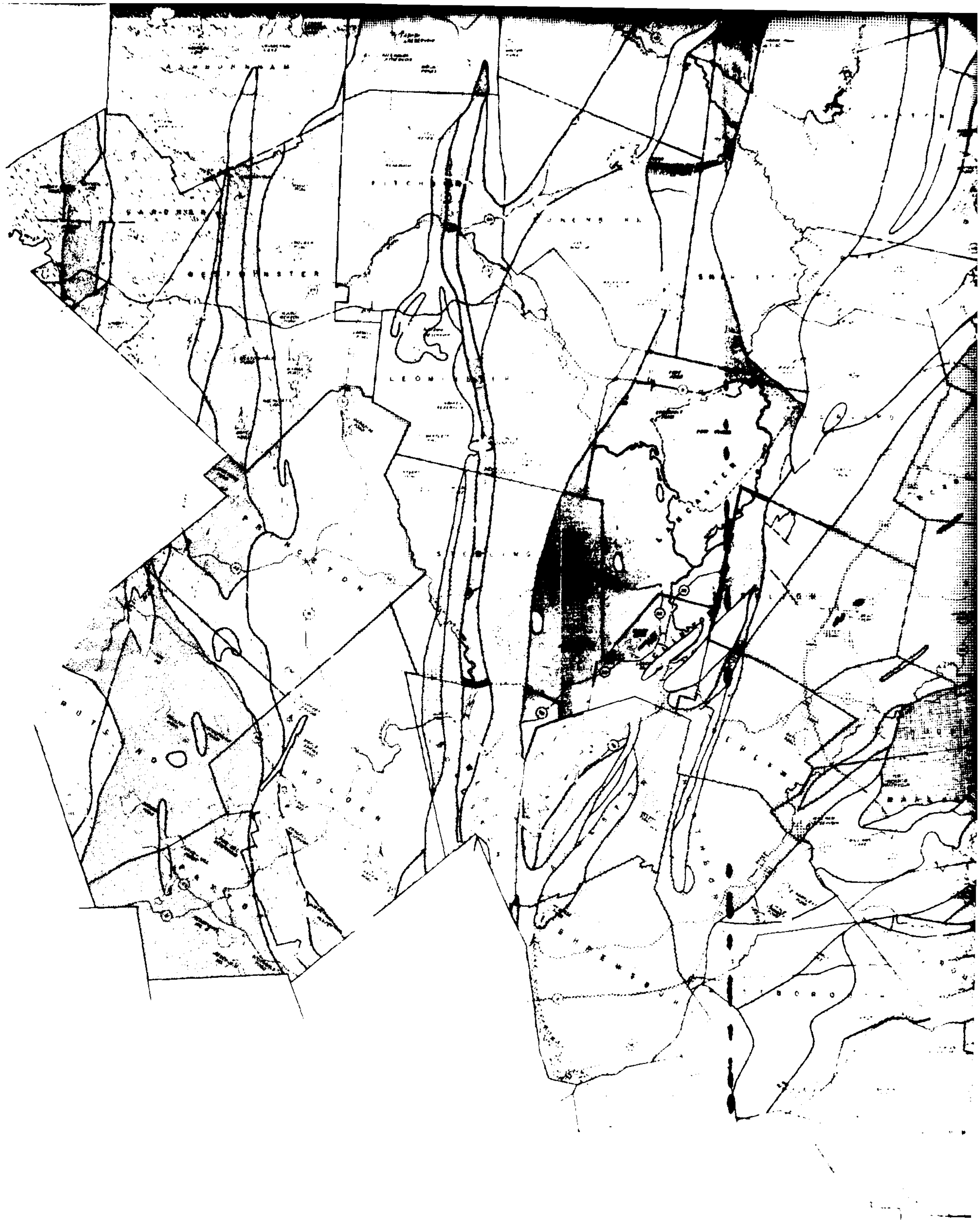


LEGEND

SYMBOL	IGNEOUS ROCK UNITS	SEDIMENTARY, META-SEDIMENTARY ROCK UNITS	SYMBOL
	DIABASE DIKES	GNEISSES & SCHISTS (TO OTHER FORMATIONS OR GROUPS)	
	PEGMATITE BODIES	HUBBARDSTON GRANITE with inclusions of BRIMFIELD SCHIST [BRIMFIELD-WARE] OR PAXTON QUARTZ SCHIST	
	BEVERLY SYENITE	**BOSTON GROUP**	
	FITCHBURG GRANITE	CAMBRIDGE SLATE	
	ANDOVER GRANITE	ROXBURY CONGLOMERATE	
	STRAW HOLLOW DIORITE & ASSABET QUARTZ DIORITE	GOSPEL HILL GNEISS	
	ACTON GRANITE	NASHOBA FORMATION	
	AYER GRANITE	BOYLSTON SCHIST	
	DRACUT DIORITE	**WORCESTER FORMATION**	
	NEWBURY AND MATTAPAN VOLCANICS	BRIMFIELD SCHIST	
	MILFORD GRANITE	WORCESTER PHYLLITE	
	DEDHAM GRANODIORITE	HARVARD CONGLOMERATE	
	NEWBURYPORT QUARTZ DIORITE	PAXTON QUARTZ SCHIST	
	SALEM GABBRO DIORITE	**MERRIMAC GROUP**	


WESTMINSTER
STERLING
HOLDEN


GROTON
WESTFORD
CHELMSFORD
TEWKSBURY
ANDOVER
LITTLETON
CARLISLE
BEDFORD
CONCORD
BURLINGTON
HARVARD
STOW
SUDBURY
FRAMINGHAM
ASHLAND
HOPKINTON
LINCOLN
SYMBOL
IG
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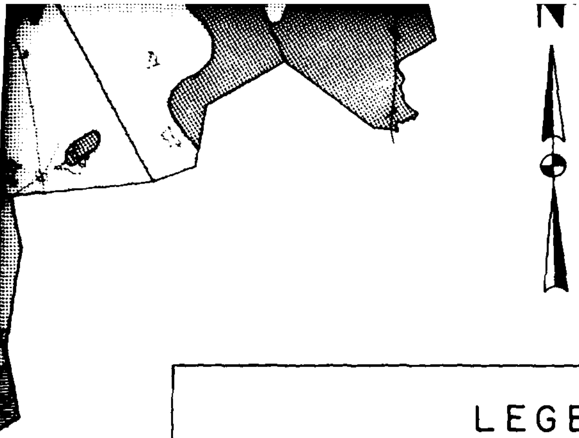


LEGEND

SYMBOL	IGNEOUS ROCK UNITS	SEDIMENTARY, META-SEDIMENTARY ROCK UNITS	SYMBOL
	DIABASE DIKES	GNEISSES & SCHISTS (TO OTHER FORMATIONS OR GROUPS)	
	PEGMATITE BODIES	HUBBARDSTON GRANITE with inclusions of BRIMFIELD SCHIST [BRIMFIELD-WARE] OR PAXTON QUARTZ SCHIST	
	BEVERLY SYENITE	BOSTON GROUP	
	FITCHBURG GRANITE	CAMBRIDGE SLATE	
	ANDOVER GRANITE	ROXBURY CONGLOMERATE	
	STRAW HOLLOW DIORITE & ASSABET QUARTZ DIORITE	GOSPEL HILL GNEISS	
	ACTON GRANITE	NASHOBA FORMATION	
	AYER GRANITE	BOYLSTON SCHIST	
	DRACUT DIORITE	WORCESTER FORMATION	
	NEWBURY AND MATTAPAN VOLCANICS	BRIMFIELD SCHIST	
	MILFORD GRANITE	WORCESTER PHYLLITE	
	DEDHAM GRANODIORITE	HARVARD CONGLOMERATE	
	NEWBURYPORT QUARTZ DIORITE	PAXTON QUARTZ SCHIST	
	SALEM GABBRO DIORITE	MERRIMAC GROUP	
	KENDALL VOLCANICS	OAKDALE QUARTZITE	
	PROBABLE FAULT	MERRIMAC QUARTZITE	
	BODY OF WATER (RIVERS, LAKES, PONDS, ETC.)	CHERRY BROOK FORMATION	
		MARLBORO FORMATION	
		WESTBORO QUARTZITE	
		RICE FORMATION	

SCALE

5 3 0 5 MILES

FIGURE B

A SUMMARY OF THE AVAILABLE INFORMAT

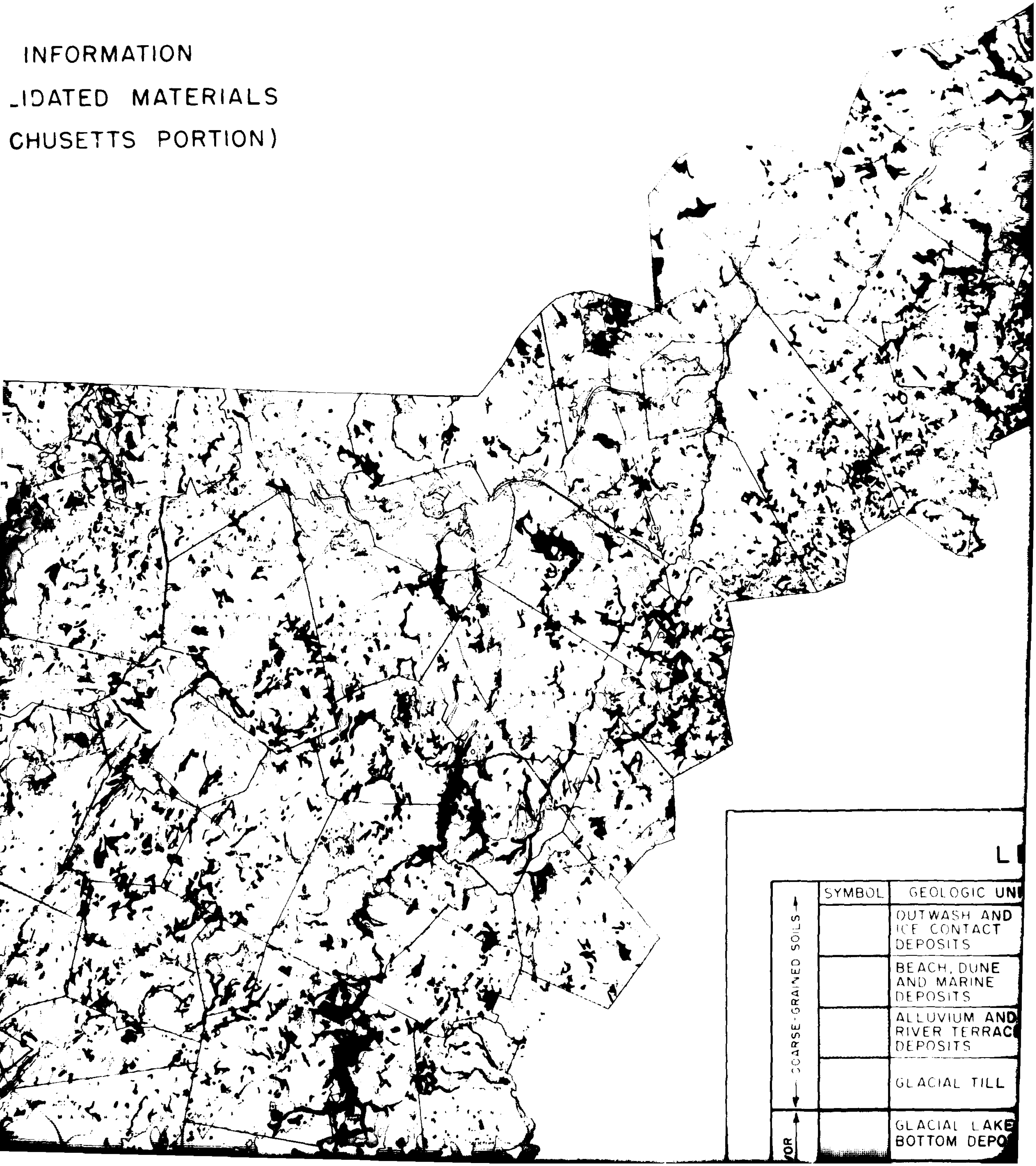
SHOWING THE DISTRIBUTION OF UNCONSOLIDATED M

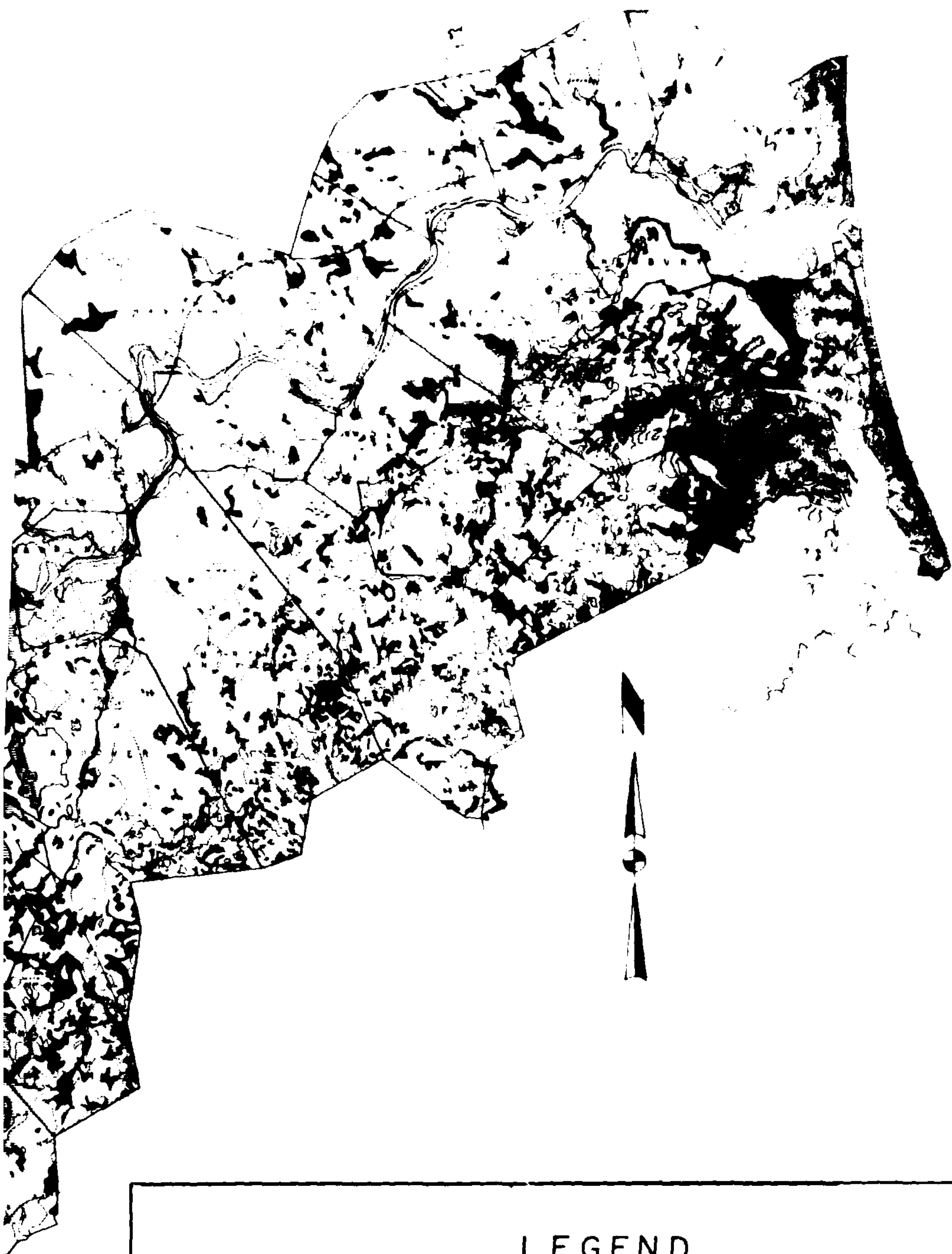
IN THE MERRIMACK RIVER BASIN (MASSACHUSETTS

INFORMATION

-IDATED MATERIALS

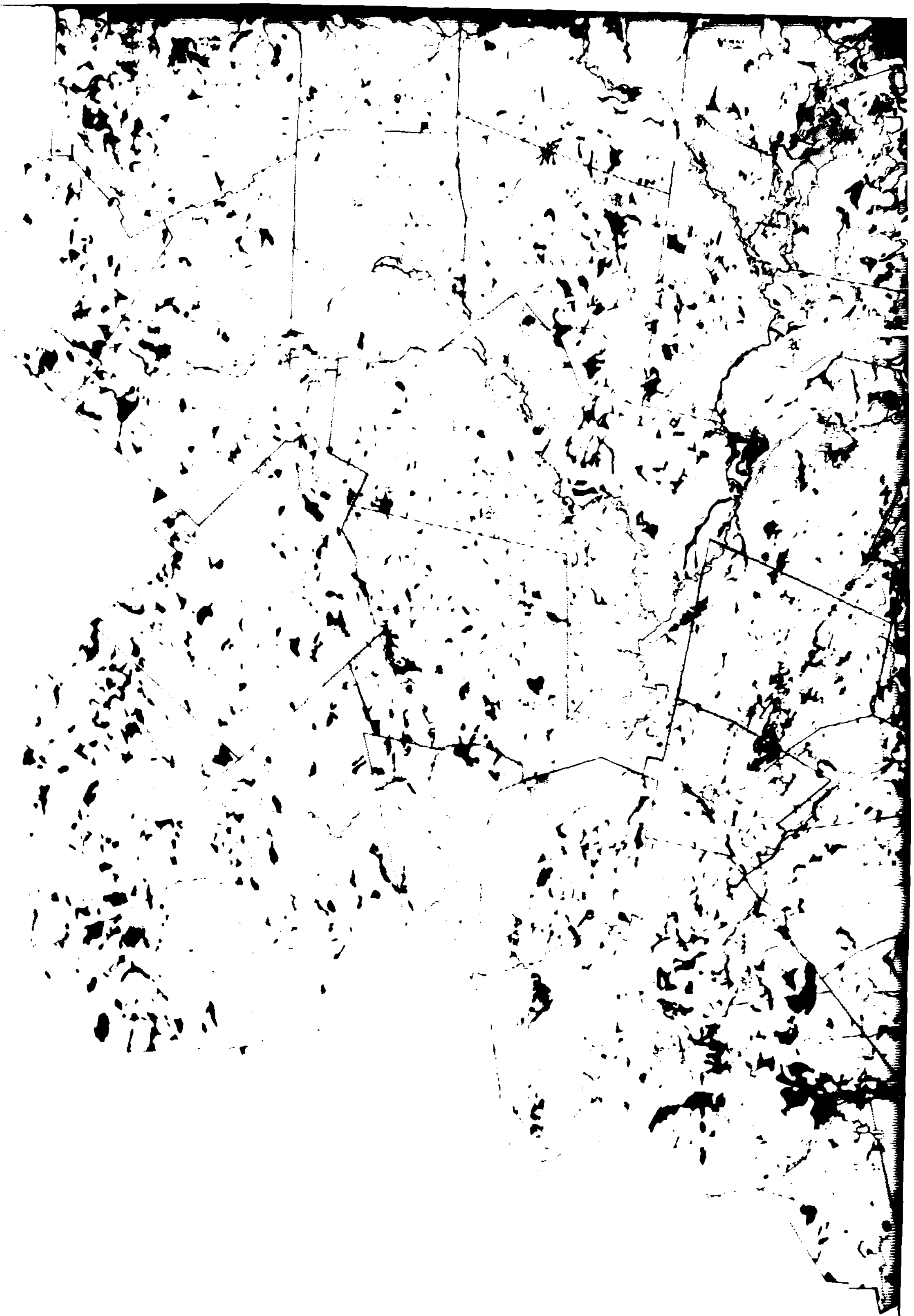
CHUSETTS PORTION)

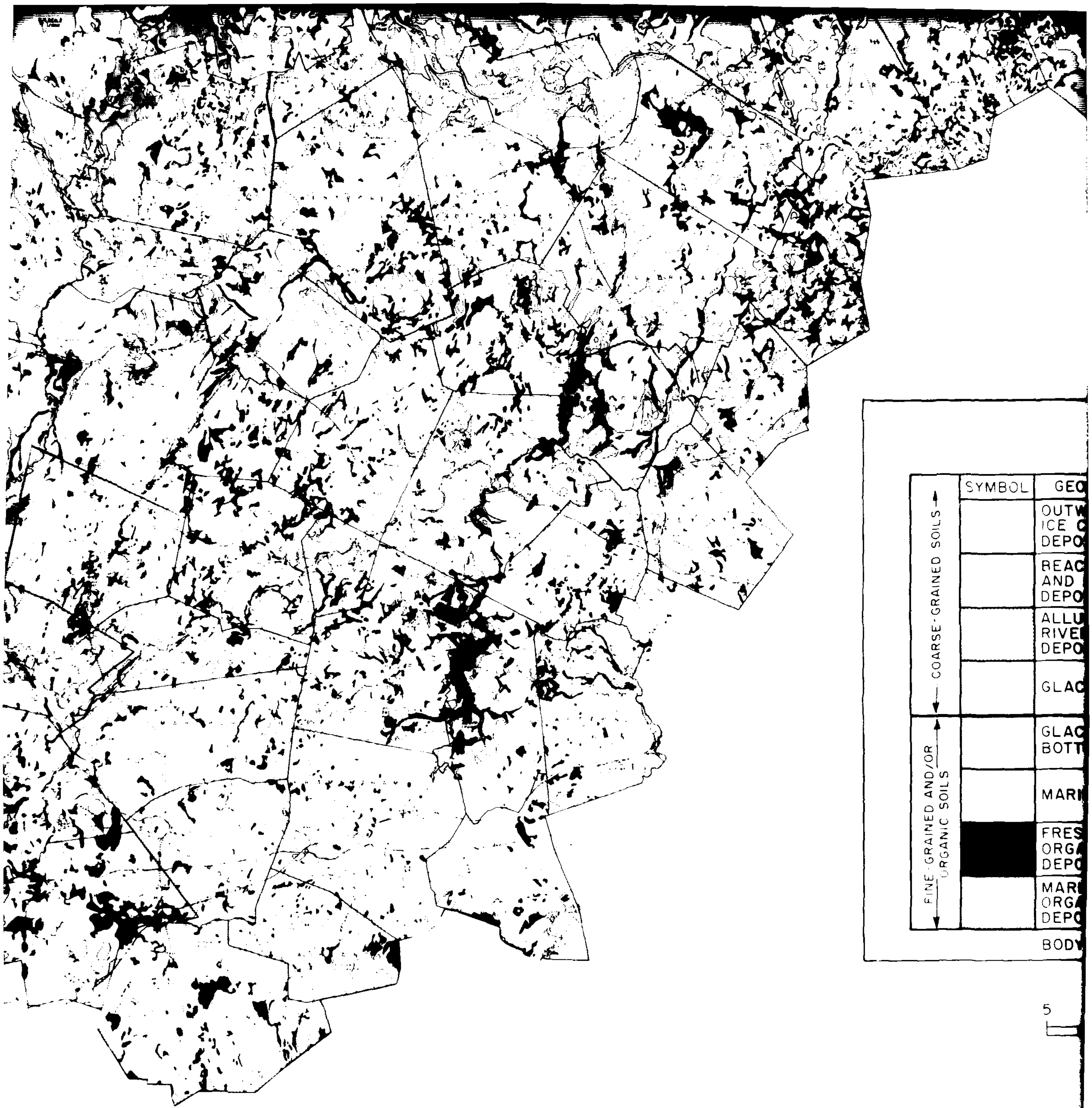




LEGEND

	SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
COARSE-GRAINED SOILS		OUTWASH AND ICE CONTACT DEPOSITS	SANDS or SANDS and GRAVELS Silt and/or clay portions usually minor - stratified and sorted
		BEACH, DUNE AND MARINE DEPOSITS	Fine or Fine to medium SANDS well sorted - often stratified and cross bedded
		ALLUVIUM AND RIVER TERRACE DEPOSITS	SAND, SILT with minor amounts of Gravel, Clay and/or Organics - poorly to moderately sorted and stratified
		GLACIAL TILL	Silty or Clayey SAND and GRAVEL with Cobbles and boulders - dense, non-stratified unsorted mixture
		GLACIAL LAKE BOTTOM DEPOSITS	SILTS, Clayey SILTS, Silty SANDS, Varved Silts and Clays




SYMBOL
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COARSE-GRAINED SOILS
OUTW ICE C DEPO
REAC AND DEPO
ALLU RIVE DEPO
GLAC
FINE-GRAINED AND/OR ORGANIC SOILS
GLAC BOTT
MARI
FRES ORGA DEPO
MARI ORGA DEPO
BODY
5

LEGEND

SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
	OUTWASH AND ICE CONTACT DEPOSITS	SANDS or SANDS and GRAVELS Silt and/or clay portions usually minor – stratified and sorted
	BEACH, DUNE AND MARINE DEPOSITS	Fine or Fine to medium SANDS well sorted – often stratified and cross bedded
	ALLUVIUM AND RIVEP TERRACE DEPOSITS	SAND, SILT with minor amounts of Gravel, Clay and/or Organics – poorly to moderately sorted and stratified
	GLACIAL TILL	Silty or Clayey SAND and GRAVEL with Cobbles and boulders – dense, non-stratified unsorted mixture
	GLACIAL LAKE BOTTOM DEPOSITS	SILTS, Clayey SILTS, Silty SANDS, Varved Silts and Clays
	MARINE DEPOSITS	Silty CLAYS, SILTS and CLAYS SILTS, Silty fine SANDS
	FRESH-WATER ORGANIC DEPOSITS	PEATS, Sandy PEATS, Silty PEATS, Organic Sands and Silts, "MUCK"
	MARINE ORGANIC DEPOSITS	ORGANIC SILT, Clayey Organic Silts, Organic Sands Marsh Mats, "Ooze"
	BODY OF WATER (Rivers, Lakes, Ponds, etc.)	

SCALE

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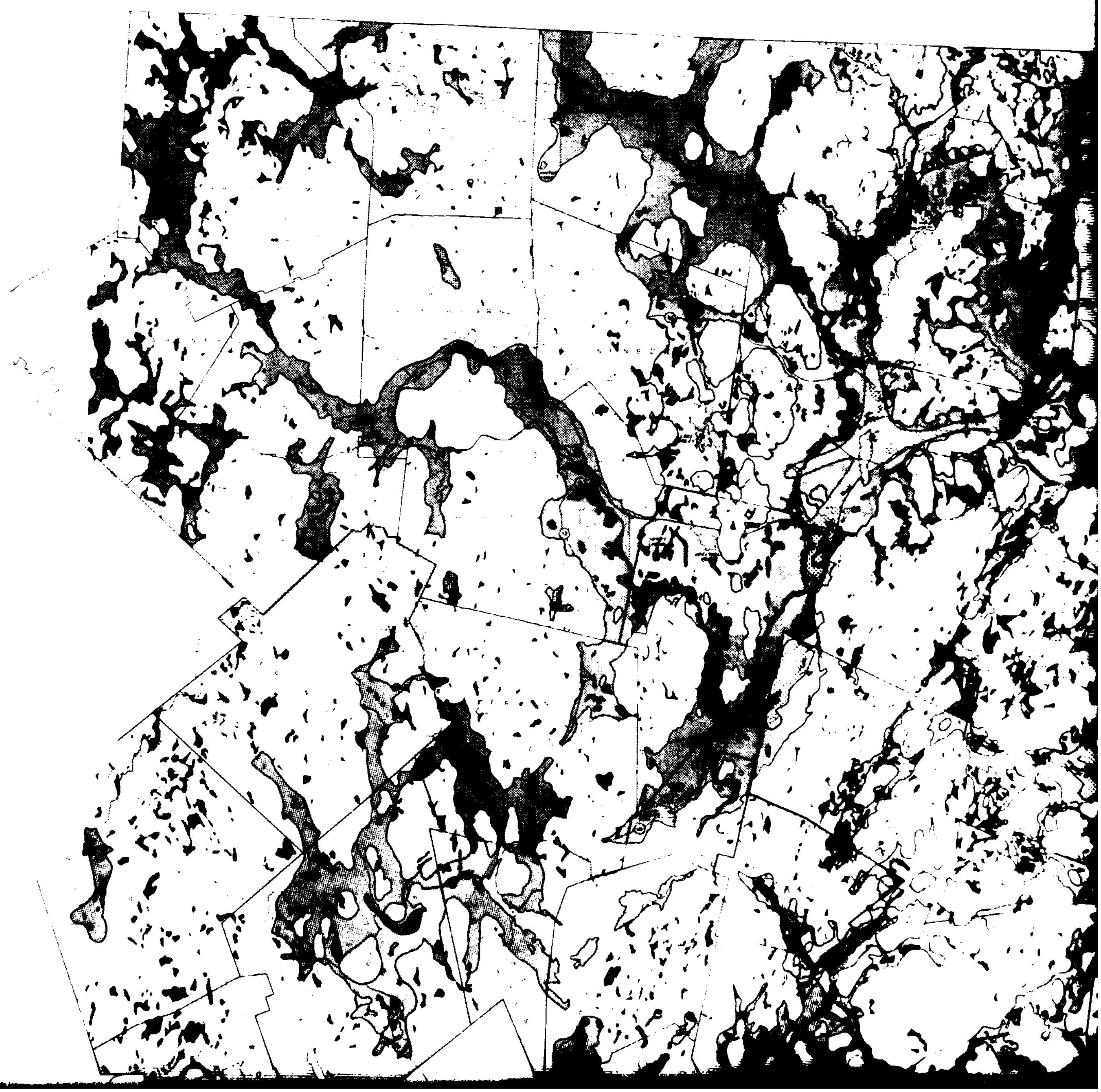
FIGURE S

PRELIMINARY ESTIMATE OF GROUND WATER FAVORABILITY IN THE MERRIMACK RIVER BASIN (MASSACHUSETTS PORTION)



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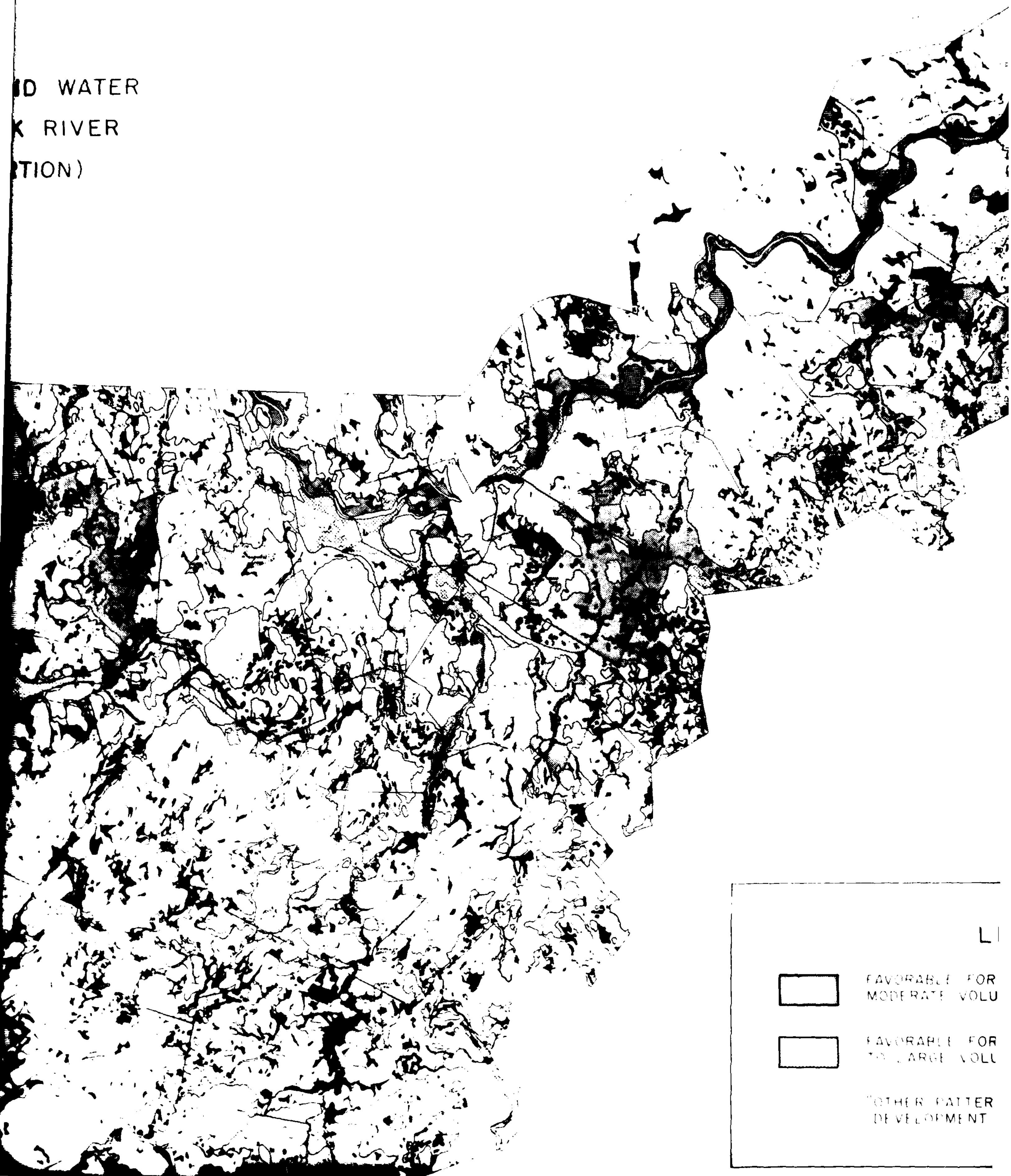

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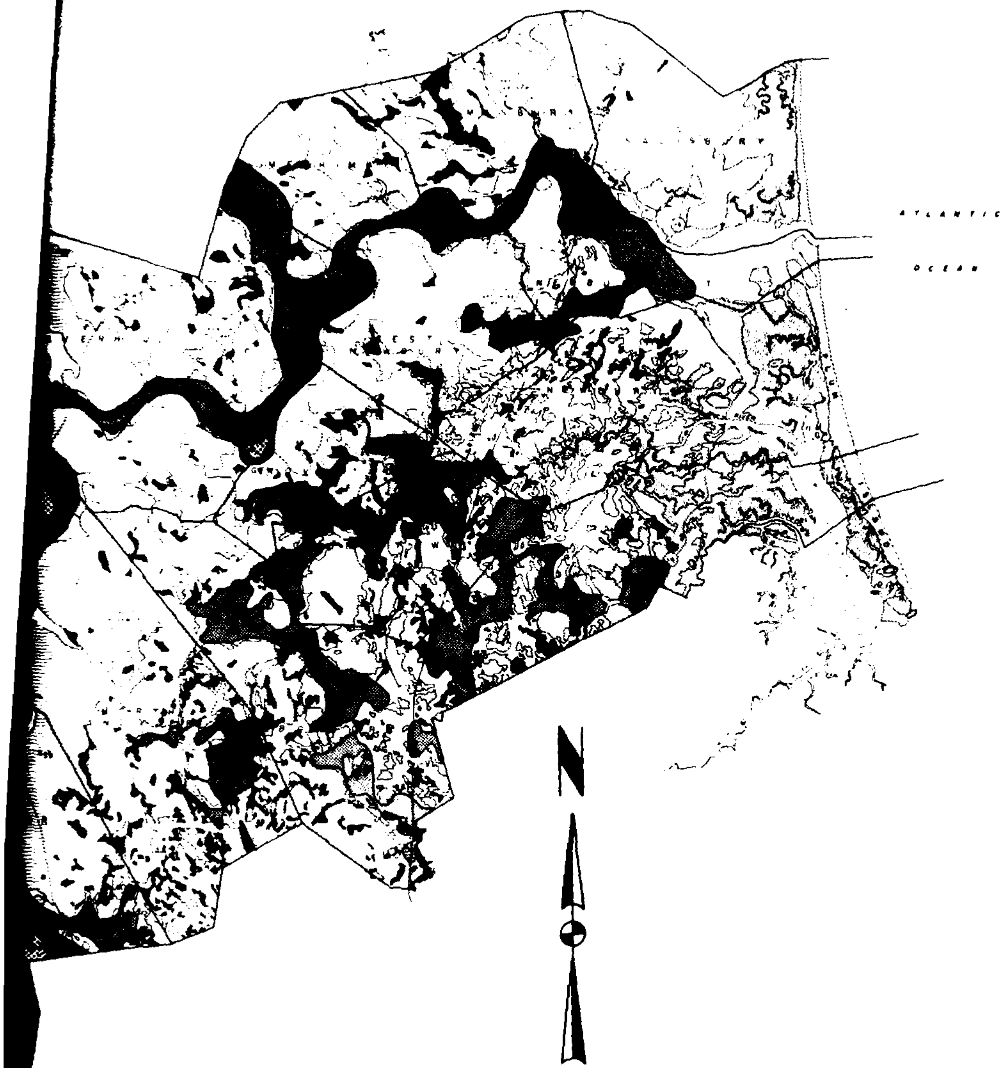
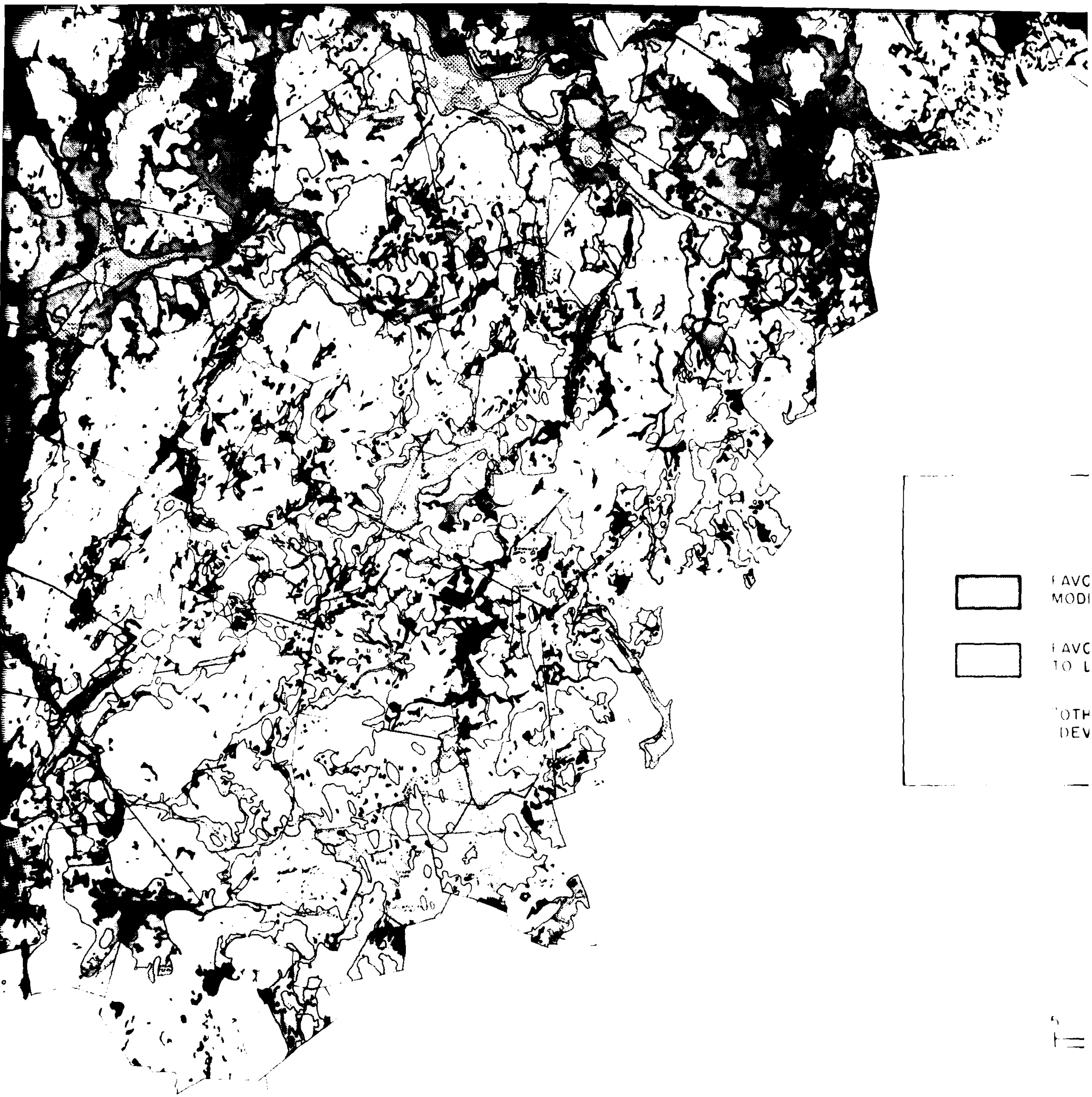


LEGEND

FAVORABLE FOR DEVELOPMENT OF LOW TO MODERATE VOLUMES OF GROUND WATER (SEE TEXT)

FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUND WATER (SEE TEXT)

"OTHER PATTERNS – UNFAVORABLE FOR DEVELOPMENT OF GROUND WATER SUPPLIES"



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LEGEND

FAVORABLE FOR DEVELOPMENT OF LOW TO MODERATE VOLUMES OF GROUND WATER (SEE TEXT)

FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUND WATER (SEE TEXT)

"OTHER PATTERNS – UNFAVORABLE FOR DEVELOPMENT OF GROUND WATER SUPPLIES"

SCALE

5 3 0 5 MILES

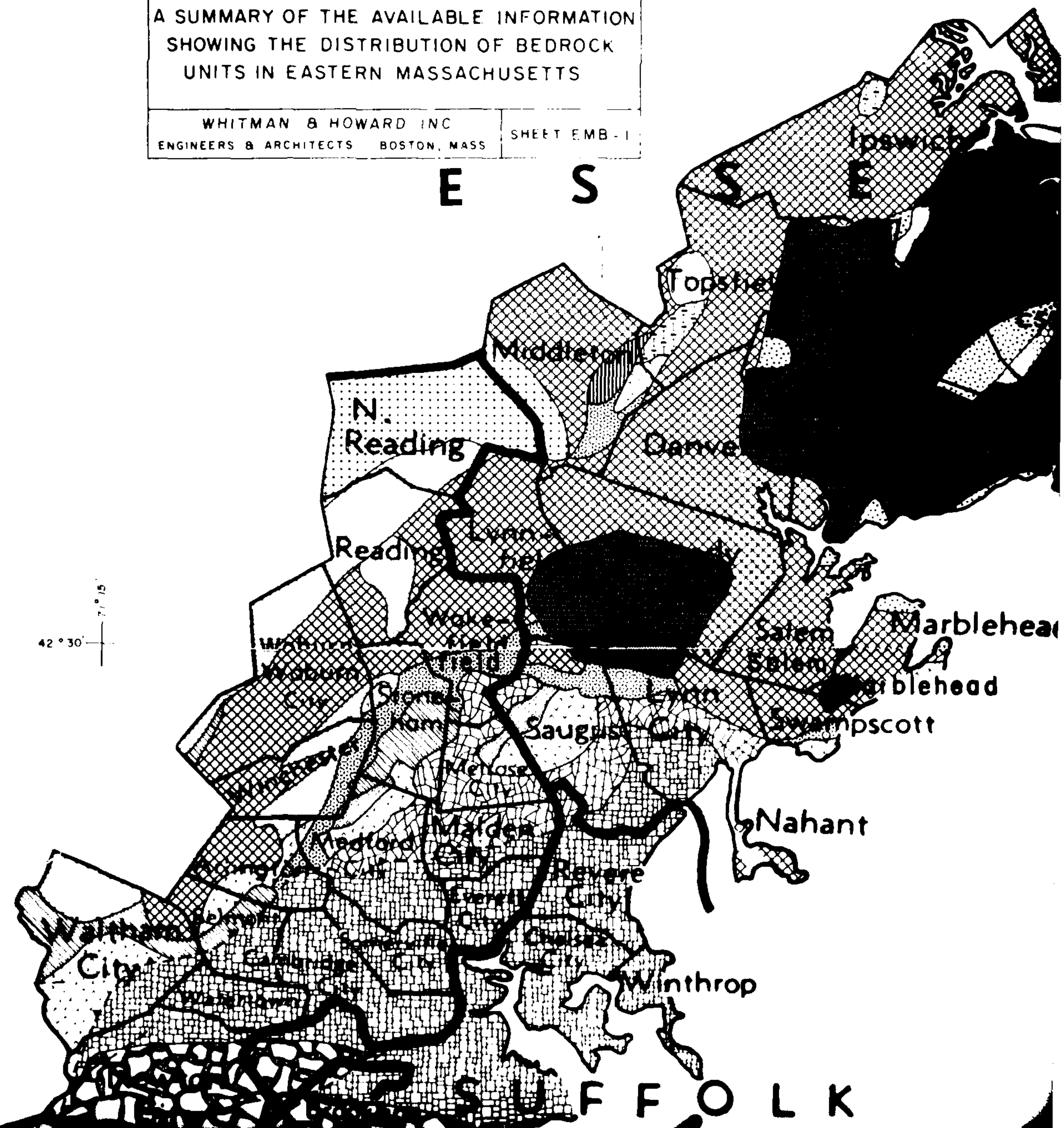
FIGURE W

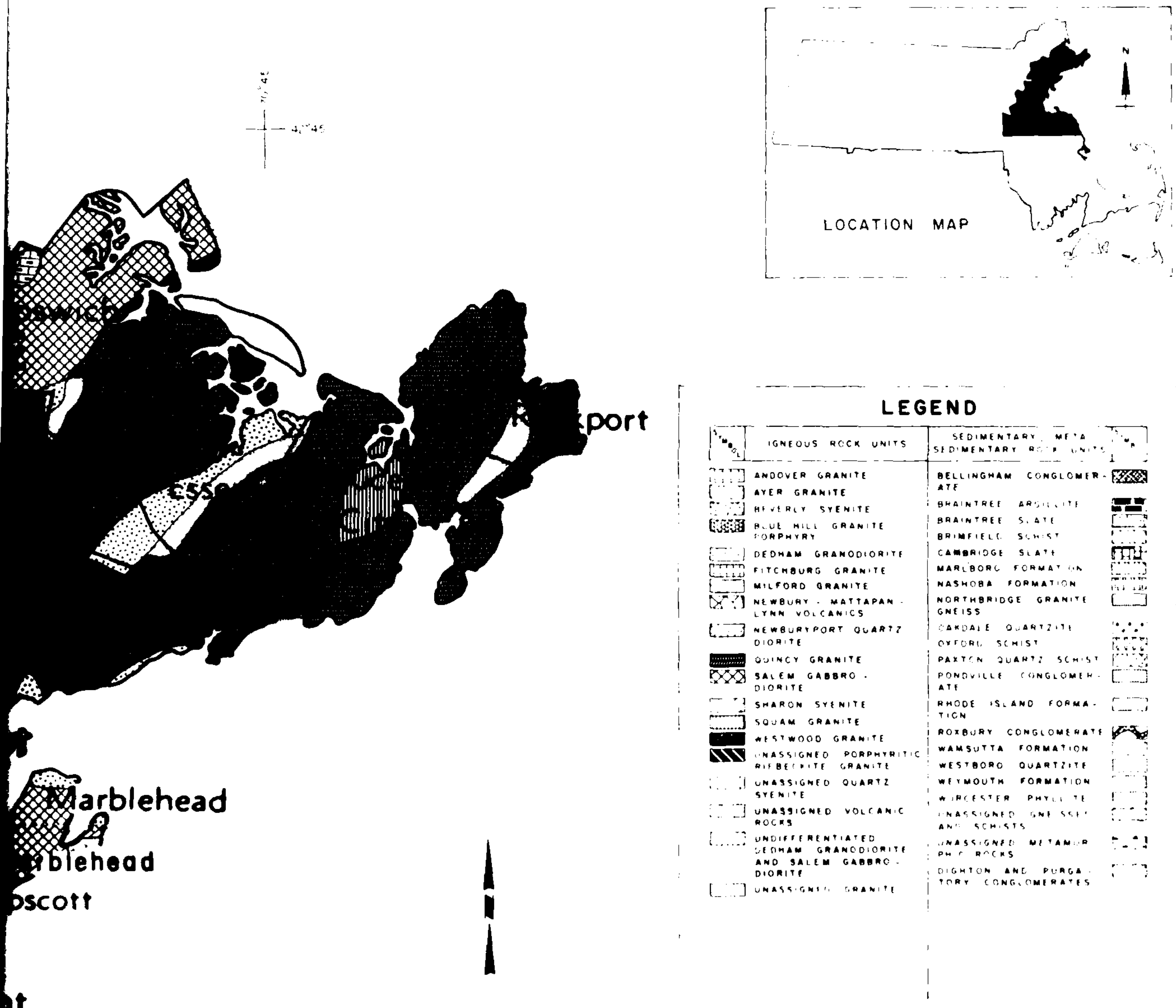
BOSTON HARBOR - EASTERN MASSACHUSETTS
METROPOLITAN AREA WASTE WATER
MANAGEMENT STUDY

UNITED STATES ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION WALTHAM, MASS

A SUMMARY OF THE AVAILABLE INFORMATION
SHOWING THE DISTRIBUTION OF BEDROCK
UNITS IN EASTERN MASSACHUSETTS

WHITMAN & HOWARD INC
ENGINEERS & ARCHITECTS BOSTON, MASS
SHEET EMB - I

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LEGEND
SYMBOL
IGNEOUS ROCK UNITS
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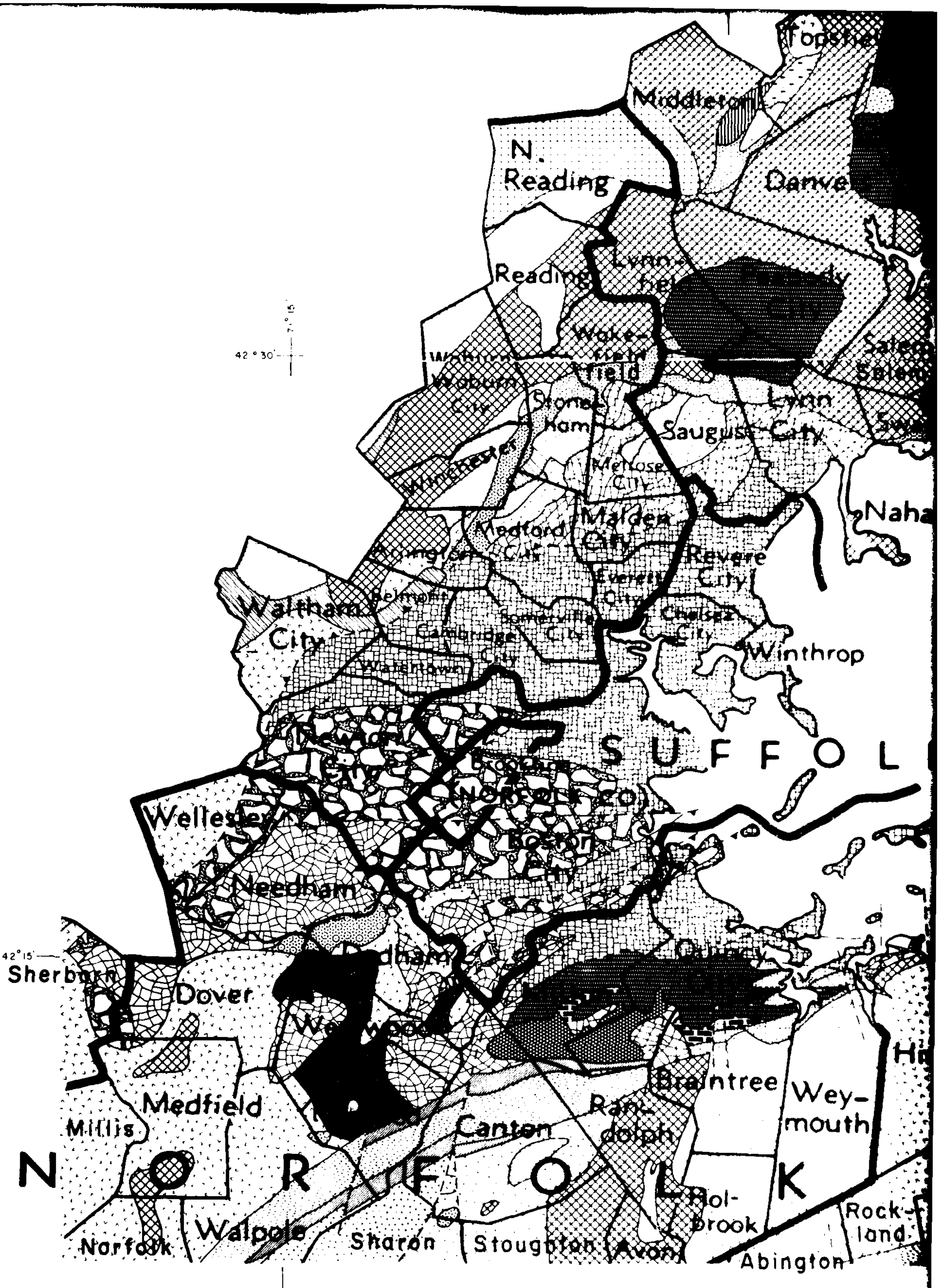
AYER GRANITE
BEVERLY SYENITE
BLUE HILL GRANITE PORPHYRY
DEDHAM GRANODIORITE
FITCHBURG GRANITE
MILFORD GRANITE
NEWBURY - MATTAPAN - LYNN VOLCANICS
NEWBURYPORT QUARTZ DIORITE
QUINCY GRANITE
SALEM GABBRO - DIORITE
SHARON SYENITE
SQUAM GRANITE
WESTWOOD GRANITE
UNASSIGNED PORPHYRITIC RIEBECKITE GRANITE
UNASSIGNED QUARTZ SYENITE
UNASSIGNED VOLCANIC ROCKS
UNDIFFERENTIATED DEDHAM GRANODIORITE AND SALEM GABBRO - DIORITE
UNASSIGNED GRANITE
SEDIMENTARY, META SEDIMENTARY ROCK UNITS
BELLINGHAM CONGLOMERATE
BRAINTREE ARGILLITE
BRAINTREE SLATE
BRIMFIELD SCHIST
CAMBRIDGE SLATE
MARLBORO FORMATION
NASHOBA FORMATION
NORTHBRIDGE GRANITE GNEISS
OAKDALE QUARTZITE
OXFORD SCHIST
PAXTON QUARTZ SCHIST
PONDVILLE CONGLOMERATE
RHODE ISLAND FORMATION
ROXBURY CONGLOMERATE
WAMSUTTA FORMATION
WESTBORO QUARTZITE
WEYMOUTH FORMATION
WORCESTER PHYLLITE
UNASSIGNED GNEISSES AND SCHISTS
UNASSIGNED METAMORPHIC ROCKS
DIGHTON AND PURGATORY CONGLOMERATES



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Medford City
Revere City
Everett City
Waltham City
Belmont
Cambridge City
Somerville City
Chelsea City
Winthrop
Watertown
Newton City
Brookline
Norfolk Co.
Boston
Wellesley
Needham
Dedham
Sherborn
Dover
Westwood
Quincy
Braintree
Wey-mouth
Medfield
Millis
Canton
Ran-dolph
N O R F O L K
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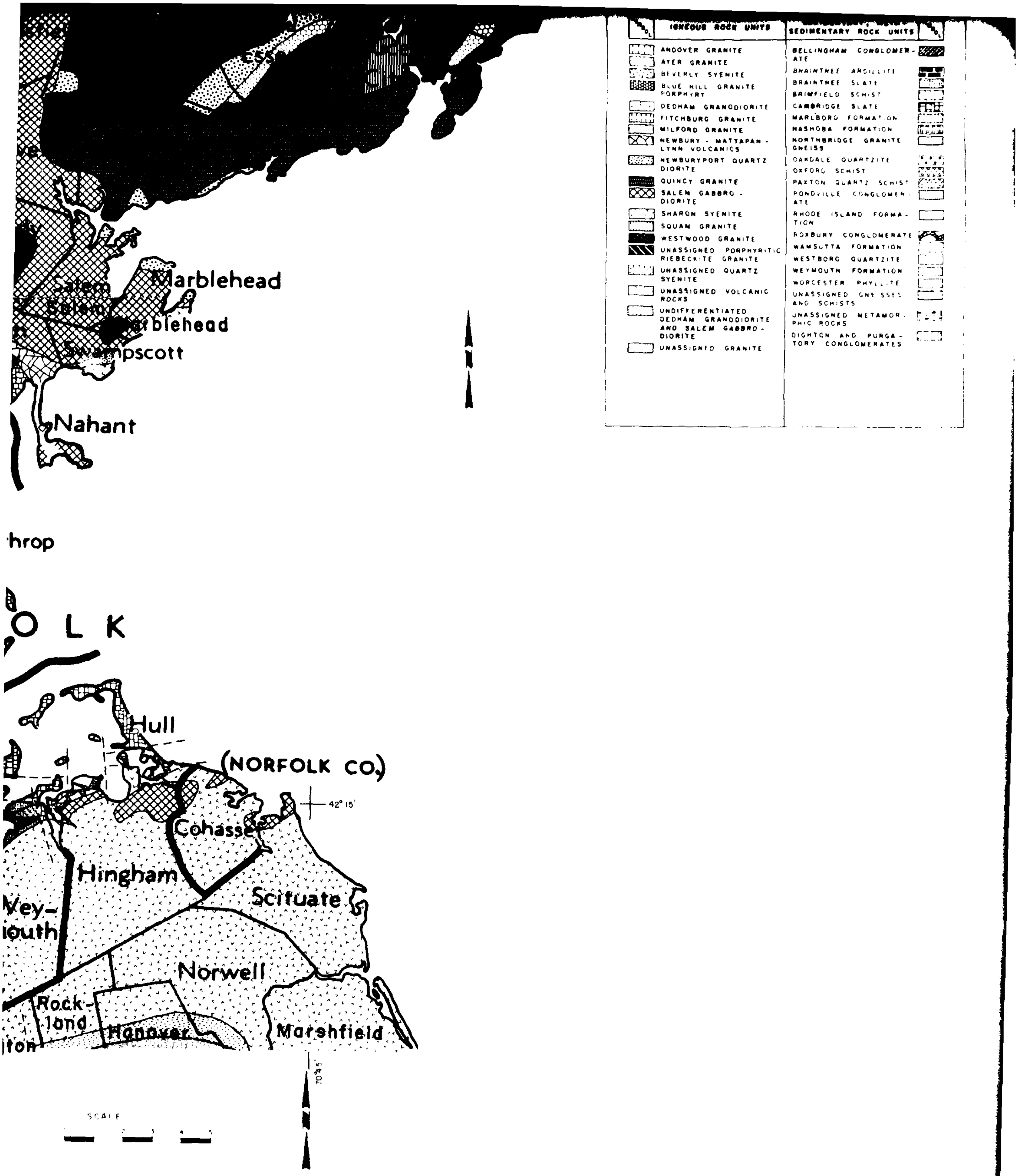
Rock-land
Walpole
Norfolk
Sharon
Stoughton
Avon
Abington



IGNEOUS ROCK UNITS
ANDOVER GRANITE
AYER GRANITE
BEVERLY SYENITE
BLUE HILL GRANITE PORPHYRY
DEDHAM GRANODIORITE
FITCHBURG GRANITE
MILFORD GRANITE
NEWBURY - MATTAPAN - LYNN VOLCANICS
NEWBURYPORT QUARTZ DIORITE
QUINCY GRANITE
SALEM GABBRO - DIORITE
SHARON SYENITE
SQUAM GRANITE
WESTWOOD GRANITE
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UNASSIGNED QUARTZ SYENITE
UNASSIGNED VOLCANIC ROCKS
UNDIFFERENTIATED DEDHAM GRANODIORITE AND SALEM GABBRO - DIORITE
UNASSIGNED GRANITE
SEDIMENTARY ROCK UNITS
BELLINGHAM CONGLOMERATE
BRAINTREE ARGILLITE
BRAINTREE SLATE
BRIMFIELD SCHIST
CAMBRIDGE SLATE
MARLBORO FORMATION
NASHOBA FORMATION
NORTHBRIDGE GRANITE GNEISS
OAKDALE QUARTZITE
OXFORD SCHIST
PAXTON QUARTZ SCHIST
PONDVILLE CONGLOMERATE
RHODE ISLAND FORMATION
ROXBURY CONGLOMERATE
WAMSUTTA FORMATION
WESTBORO QUARTZITE
WEYMOUTH FORMATION
WORCESTER PHYLLITE
UNASSIGNED GNEISSES AND SCHISTS
UNASSIGNED METAMORPHIC ROCKS
DIGHTON AND PURGATORY CONGLOMERATES
Marblehead
Salem
Marblehead
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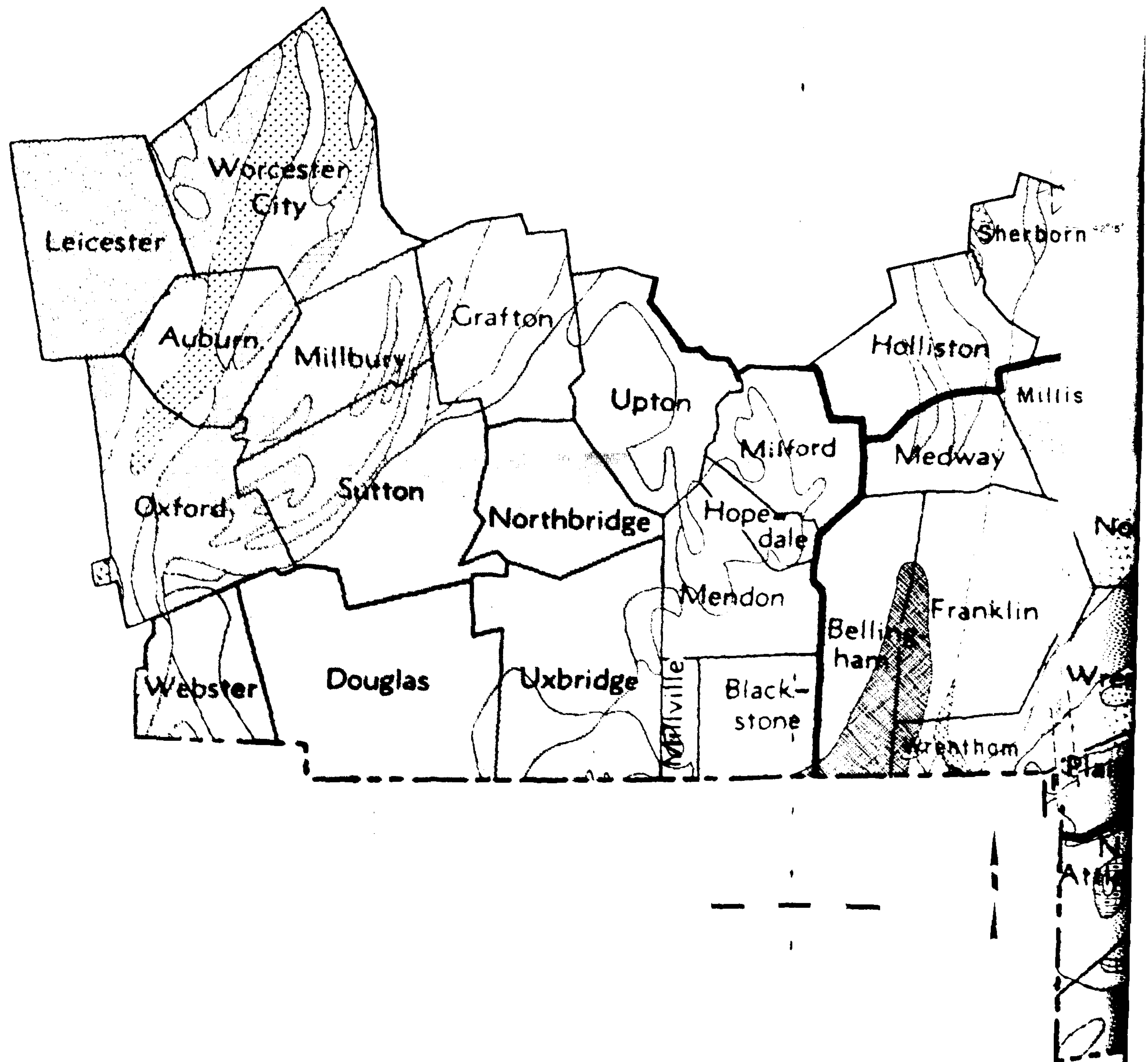
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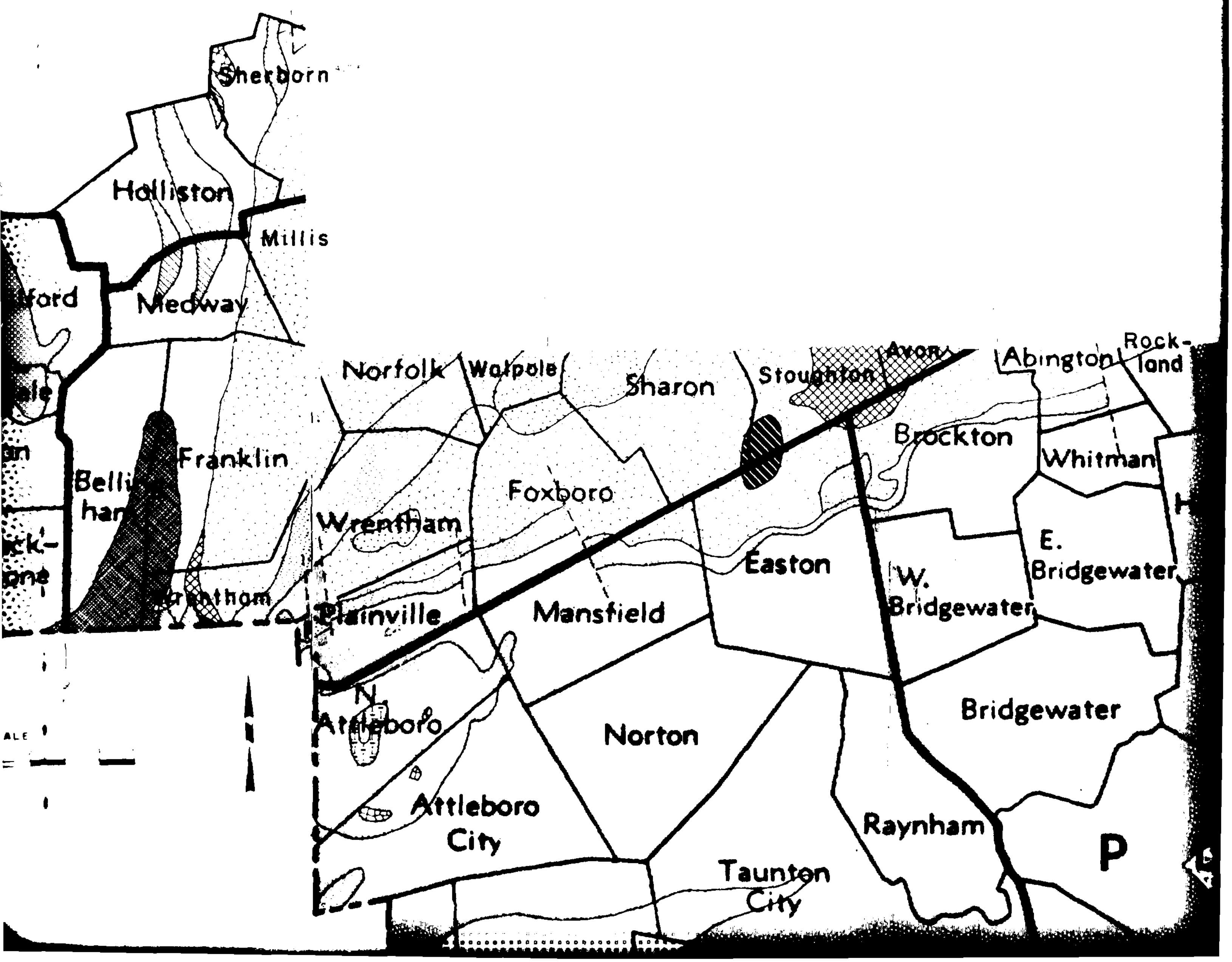

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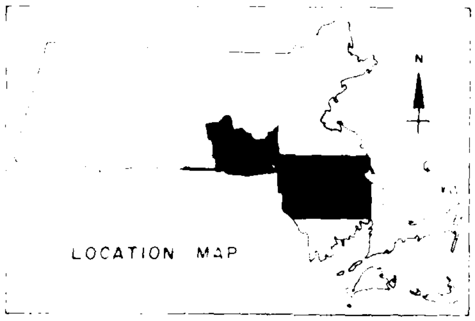
LOCATION MAP
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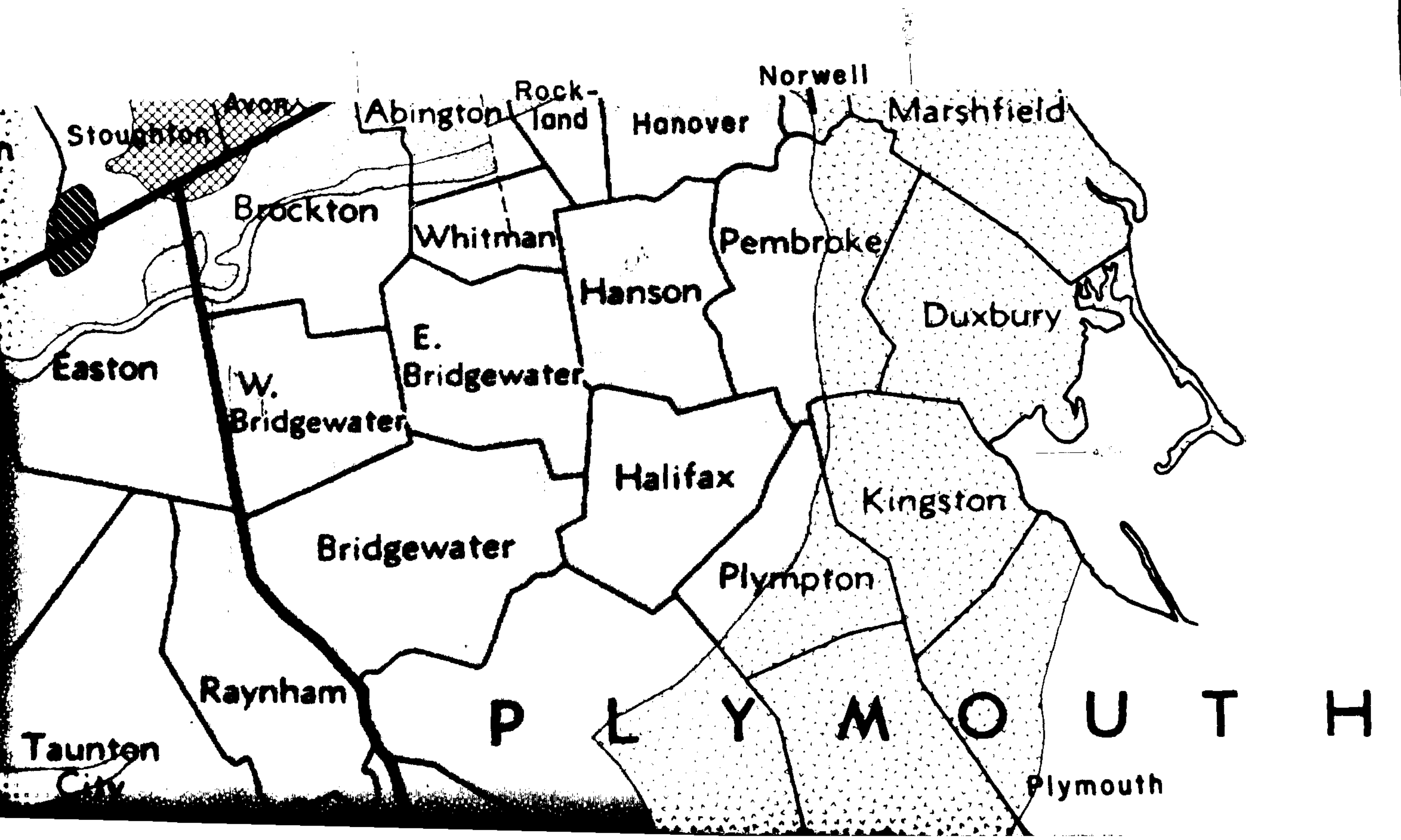
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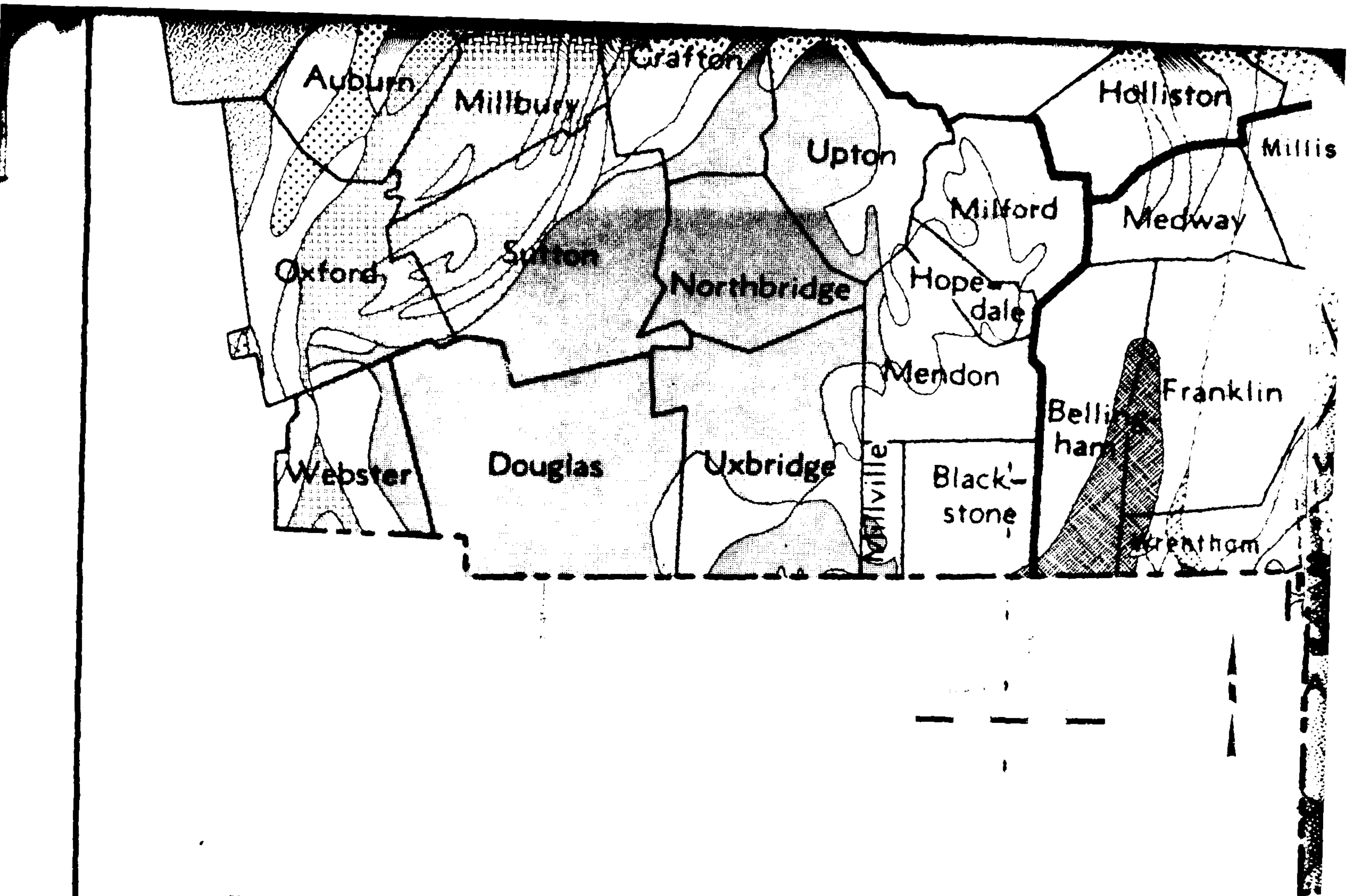

BOSTON HARBOR - EASTERN MASSACHUSETTS
METROPOLITAN AREA WASTE WATER
MANAGEMENT STUDY

UNITED STATES ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION WALTHAM, MASS.

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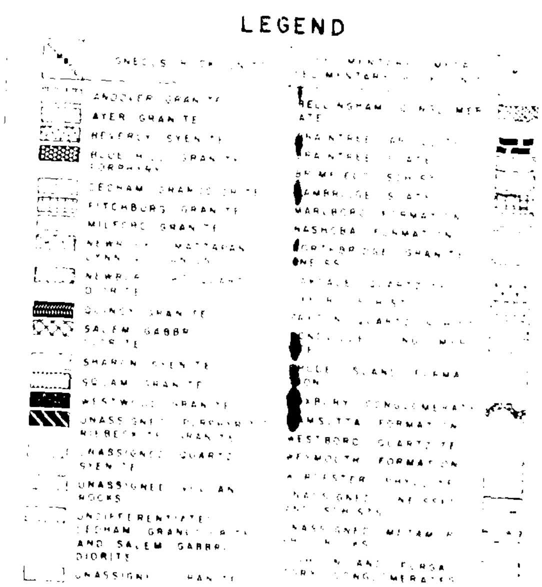
UNITS IN EASTERN MASSACHUSETTS

WHITMAN & HOWARD INC
ENGINEERS & ARCHITECTS BOSTON, MASS

SHEET EMB-2



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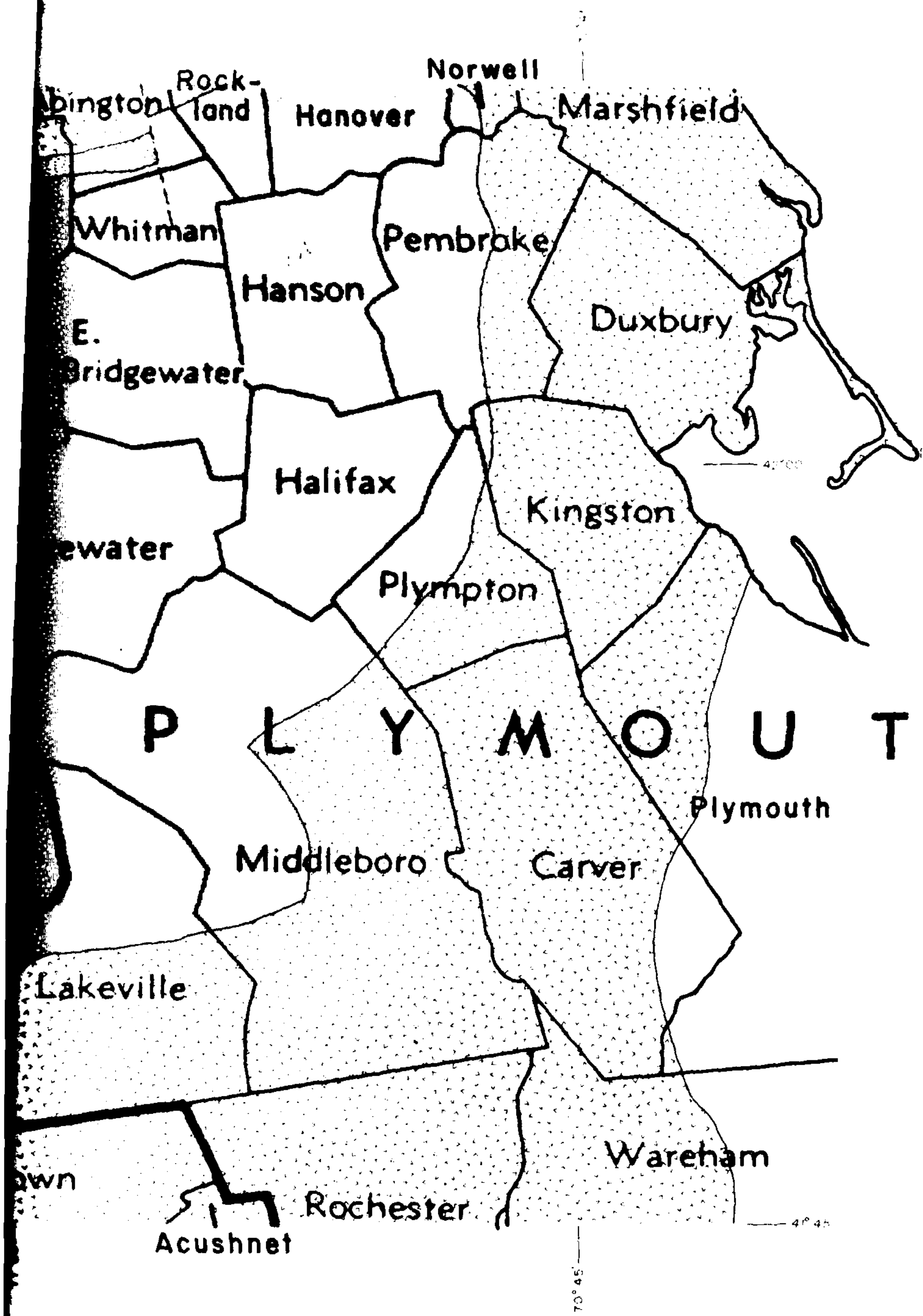
Hanson
Foxboro
Wrentham
Easton
E.
Bridgewater
W.
Bridgewater
Wrentham
Plainville
Mansfield
N.
Attleboro
Norton
Bridgewater
Attleboro
City
Raynham
P
L
Taunton
City
Middleb
B R I S T O L
Seekonk
Rehoboth
Dighton
Berkley
Lakeville
Somerset
Swansea
Fall River
Freetown
Acushnet
ND


Norwell
Rock-
land
bington
Hanover
Marshfield
Whitman
Pembroke
Hanson
Duxbury
E.
Bridgewater
Halifax
Kingston
ewater
Plympton
P L Y M O U T H
Plymouth
Middleboro
Carver
Lakeville
Wareham
wn
Rochester
Acushnet
70° 45'

BOSTON HARBOR - EASTERN MASSACHUSETTS
METROPOLITAN AREA WASTE WATER
MANAGEMENT STUDY

UNITED STATES ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION WALTHAM, MASS.

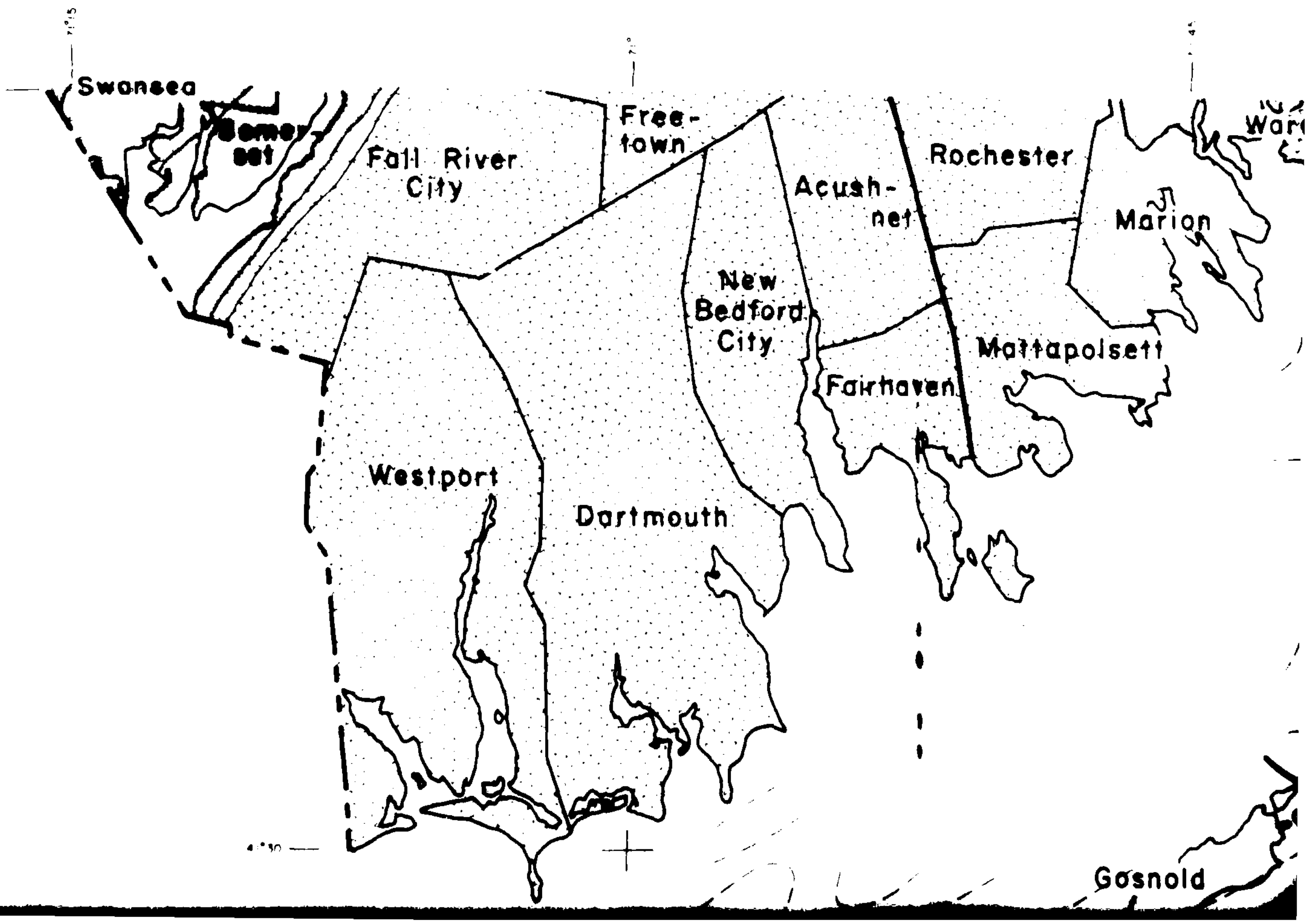
A SUMMARY OF THE AVAILABLE INFORMATION SHOWING THE DISTRIBUTION OF BEDROCK UNITS IN EASTERN MASSACHUSETTS

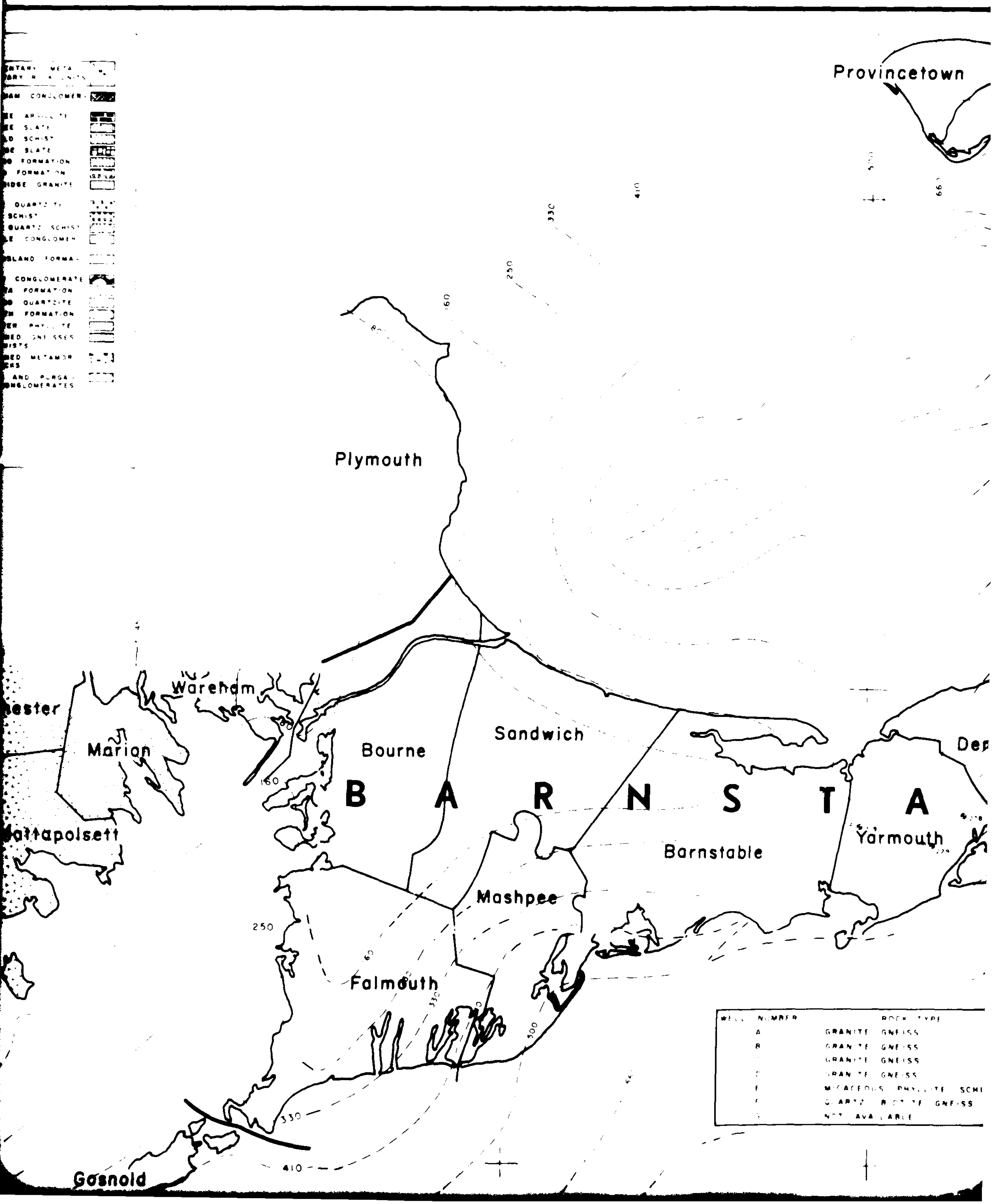
WHITMAN & HOWARD INC.
ENGINEERS & ARCHITECTS BOSTON, MASS

SHEET EMB-3

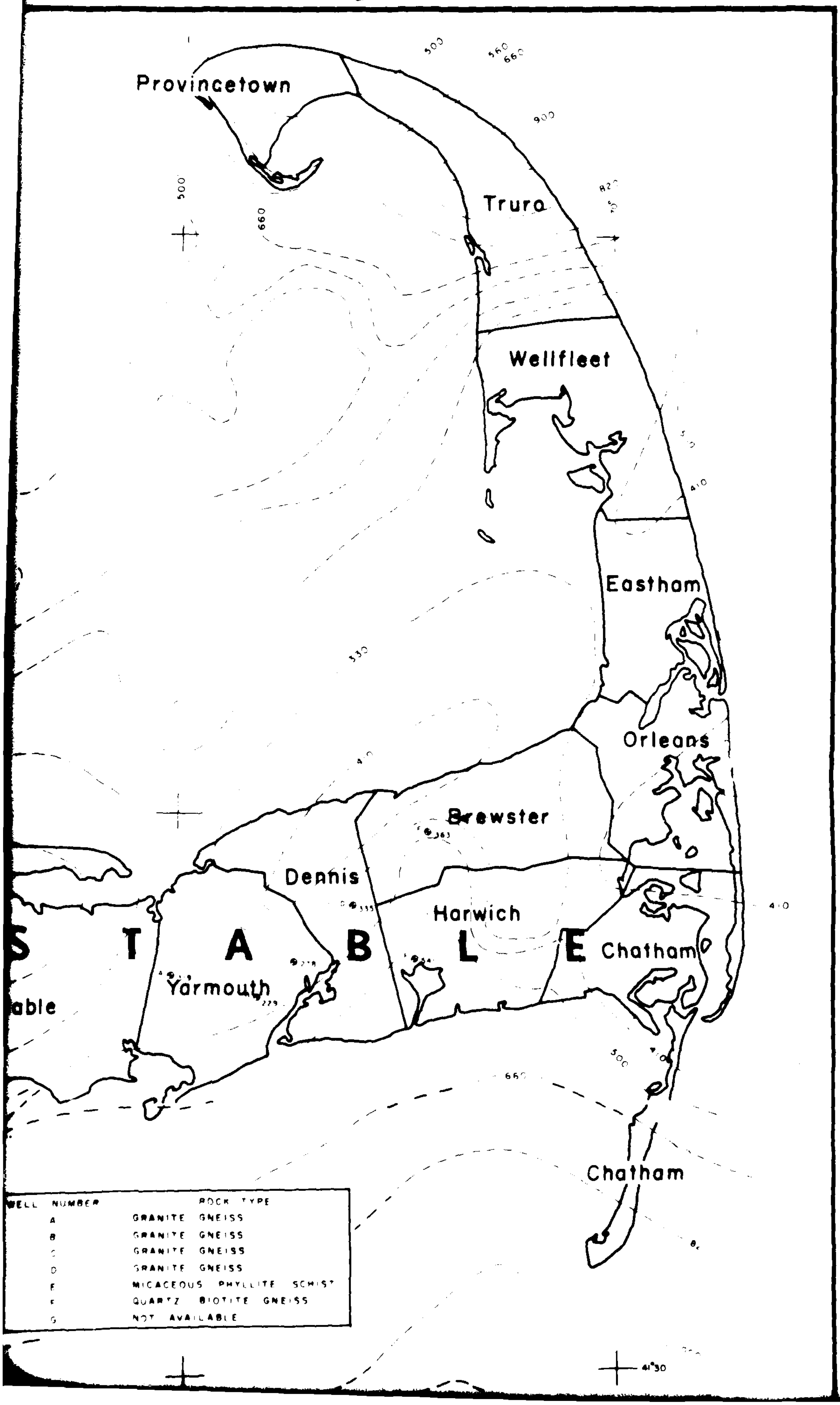
LEGEND

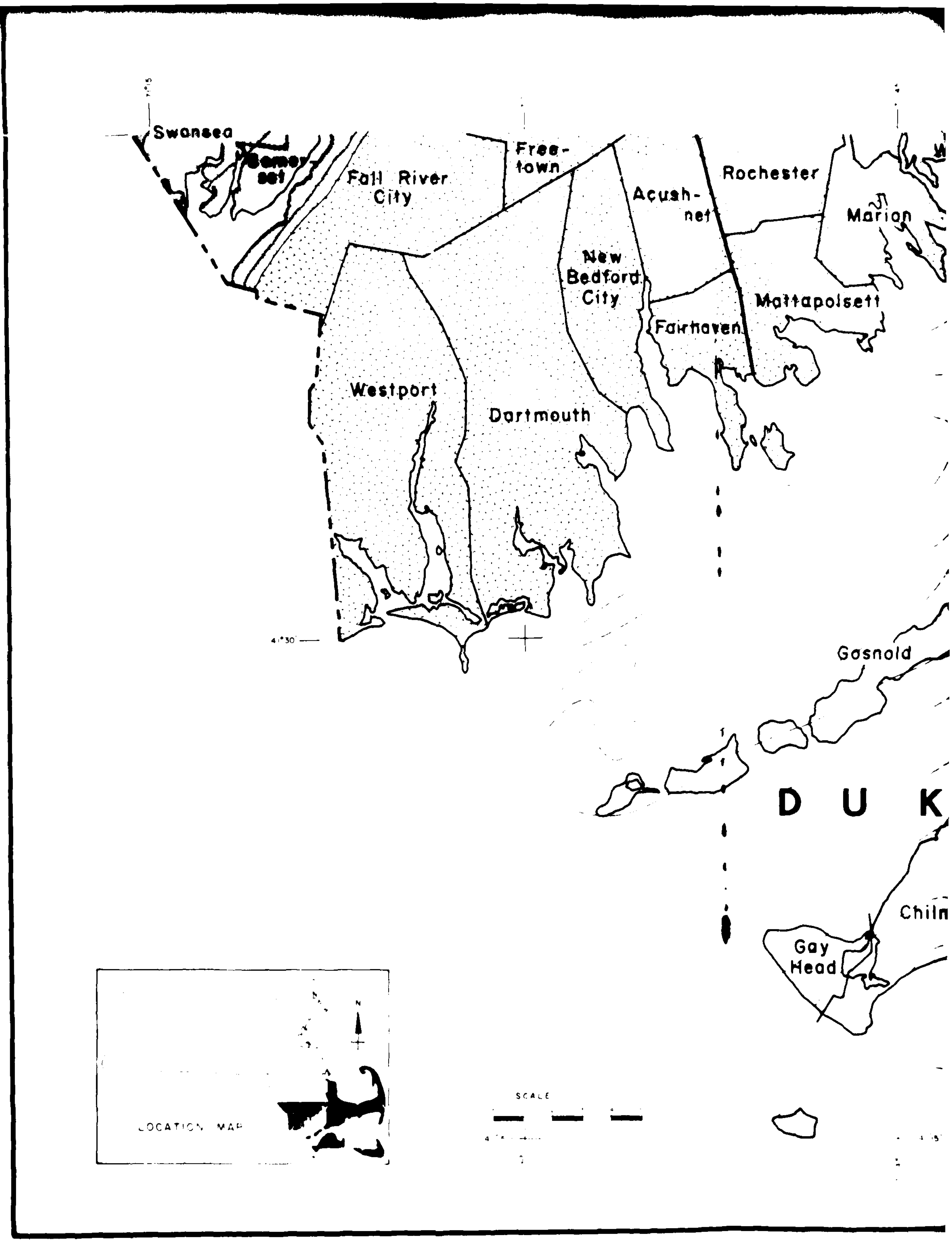
IGNEOUS ROCK UNITS	SEDIMENTARY, METASEDIMENTARY ROCK UNITS
ANDOVER GRANITE	BELLINGHAM CONGLOMERATE
AYER GRANITE	BRAINTREE ARGILLITE
BEVERLY SYENITE	BRAINTREE SLATE
BLUE HILL GRANITE PORPHYRY	BRIMFIELD SCHIST
DEDHAM GRANODIORITE	CAMBRIDGE SLATE
FITCHBURG GRANITE	MARLBORO FORMATION
MILFORD GRANITE	NASHOBA FORMATION
NEWBURY - MATTAPAN - LYNN VOLCANICS	NORTHBRIDGE GRANITE GNEISS
NEWBURYPORT QUARTZ DIORITE	CARDALE QUARTZITE
QUINCY GRANITE	OXFORD SCHIST
SALEM GABBRO - DIORITE	PAXTON QUARTZ SCHIST
SHARON SYENITE	PONDVILLE CONGLOMERATE
SQUAM GRANITE	RHODE ISLAND FORMATION
WESTWOOD GRANITE	ROXBURY CONGLOMERATE
UNASSIGNED PORPHYRITIC RIEBECKITE GRANITE	WAMSUTTA FORMATION
UNASSIGNED QUARTZ SYENITE	WESTBORO QUARTZITE
UNASSIGNED VOLCANIC ROCKS	WEYMOUTH FORMATION
UNDIFFERENTIATED DEDHAM GRANODIORITE AND SALEM GABBRO - DIORITE	WORCESTER PHYLLITE
UNASSIGNED GRANITE	UNASSIGNED GNEISSES AND SCHISTS
	UNASSIGNED METAMORPHIC ROCKS
	DIGHTON AND PURGATORY CONGLOMERATES



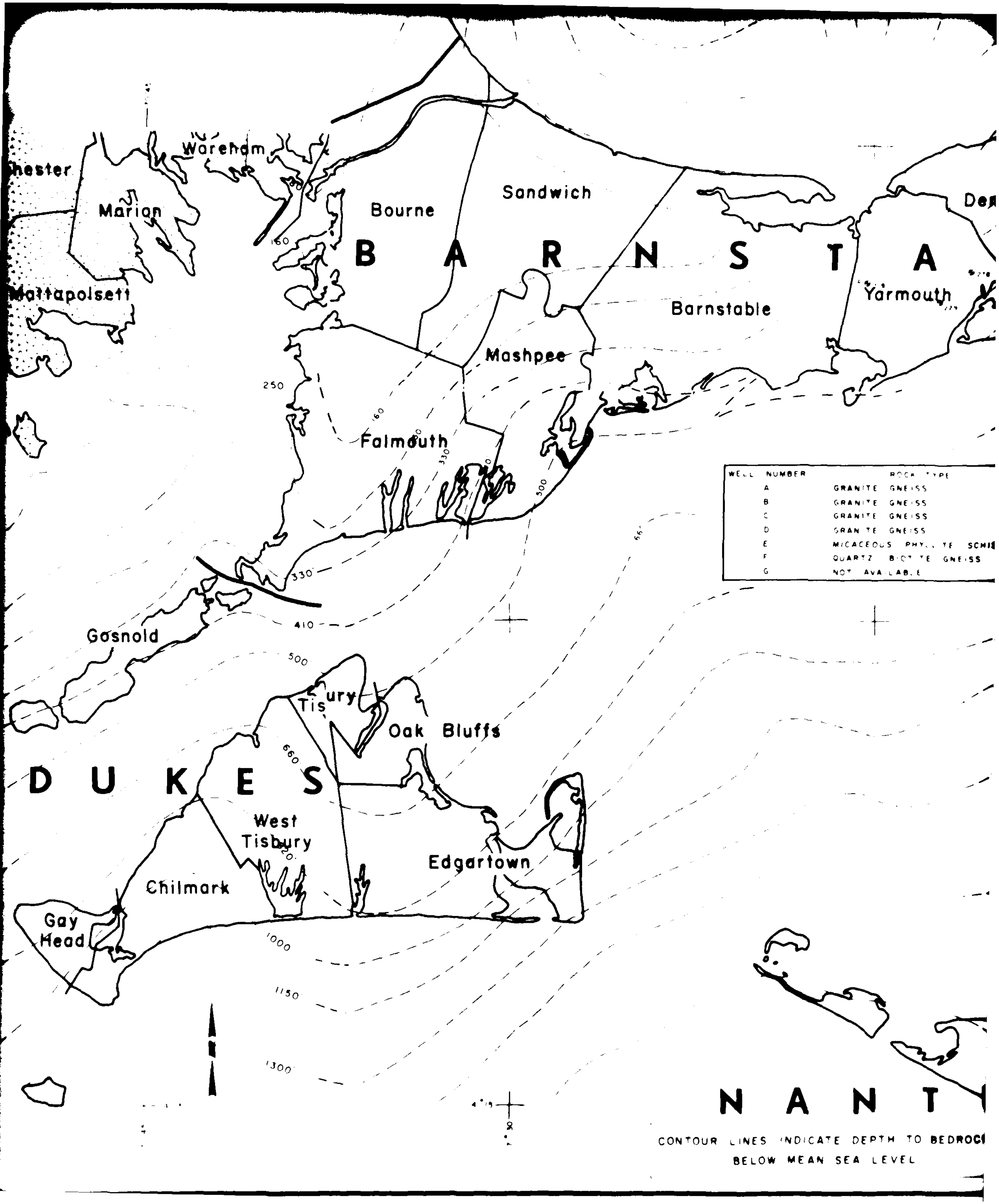


CONGLOMERATE
SLATE
SCHIST
SLATE
FORMATION
FORMATION
GRANITE
SCHIST
FORMATION
QUARTZITE
FORMATION
CONGLOMERATES
Provincetown
Plymouth
Wareham
Marion
Bourne
Sandwich
BARNSTA
Barnstable
Yarmouth
Mashpee
Falmouth
Gosnold
410
330
250
160
300
WELL NUMBER ROCK TYPE
A GRANITE GNEISS
B GRANITE GNEISS
GRANITE GNEISS
GNEISS
GNEISS

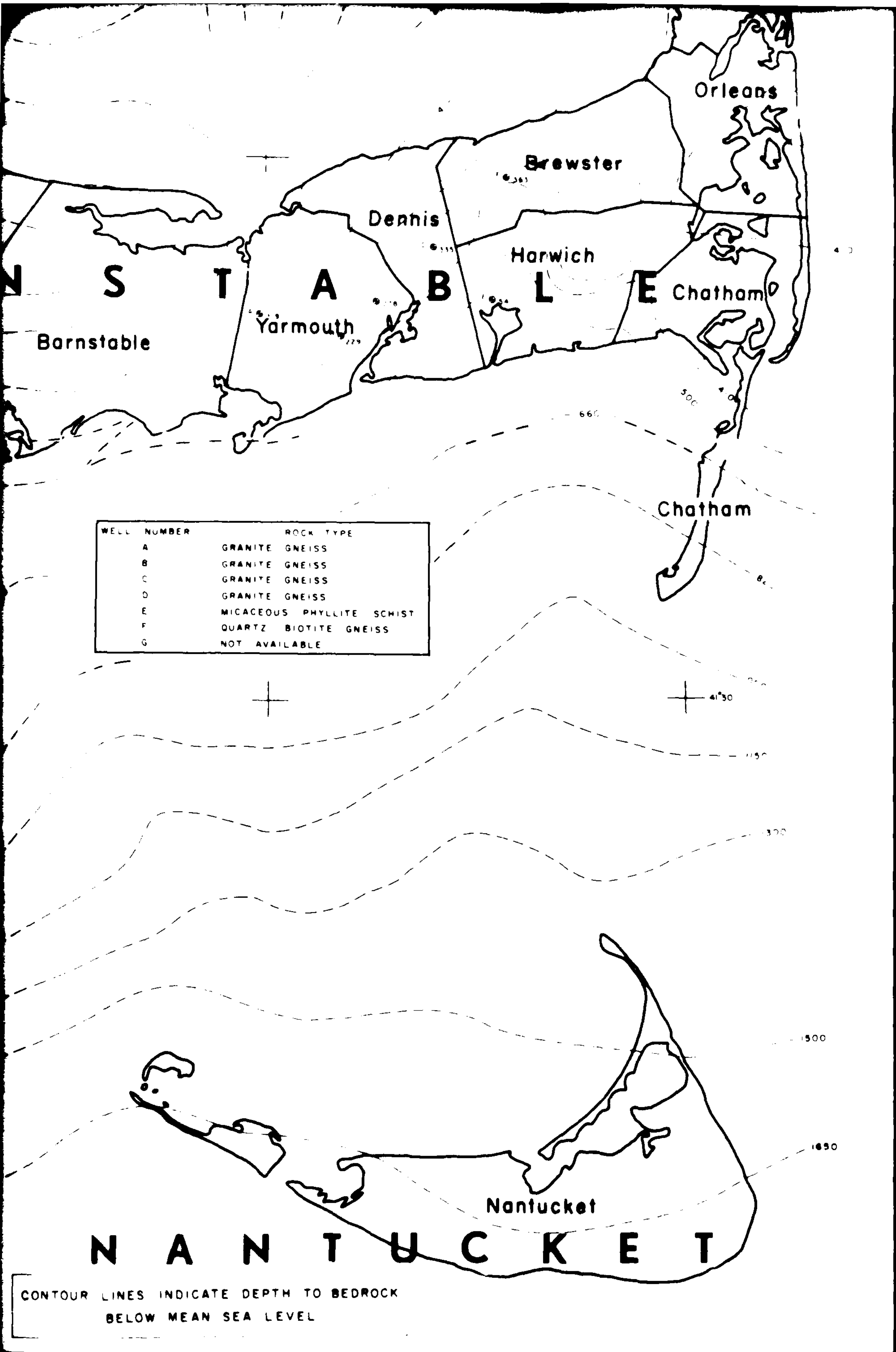

Provincetown
Truro
Wellfleet
Eastham
Orleans
Brewster
Dennis
Harwich
Chatham
Yarmouth
able
S T A B L E
Chatham
WELL NUMBER
ROCK TYPE
A GRANITE GNEISS
B GRANITE GNEISS
C GRANITE GNEISS
D GRANITE GNEISS
E MICACEOUS PHYLLITE SCHIST
F QUARTZ BIOTITE GNEISS
G NOT AVAILABLE
41°30



Swansea
Somerset
Fall River City
Free-town
Acush-net
Rochester
Marion
New Bedford City
Mattapoisett
Fairhaven
Westport
Dartmouth
Gosnold
D U K
Chilm
Gay Head
LOCATION MAP
SCALE



Wareham
hester
Marion
Mattapoisett
Bourne
Sandwich
B A R N S T A
Barnstable
Yarmouth
Mashpee
Falmouth
Gosnold
Tisbury
Oak Bluffs
D U K E S
West Tisbury
Edgartown
Chilmark
Gay Head
N A N T
160
250
330
410
500
660
1000
1150
1300
WELL NUMBER ROCK TYPE
A GRANITE GNEISS
B GRANITE GNEISS
C GRANITE GNEISS
D GRANITE GNEISS
E MICACEOUS PHYLLITE SCHIS
F QUARTZ BIOTITE GNEISS
G NOT AVAILABLE
CONTOUR LINES INDICATE DEPTH TO BEDROCK
BELOW MEAN SEA LEVEL


Orleans
Brewster
Dennis
Harwich
BARNSTABLE
Chatham
Barnstable
Yarmouth
Chatham
WELL NUMBER ROCK TYPE
A GRANITE GNEISS
B GRANITE GNEISS
C GRANITE GNEISS
D GRANITE GNEISS
E MICACEOUS PHYLLITE SCHIST
F QUARTZ BIOTITE GNEISS
G NOT AVAILABLE
1500
1650
Nantucket
NANTUCKET
CONTOUR LINES INDICATE DEPTH TO BEDROCK
BELOW MEAN SEA LEVEL

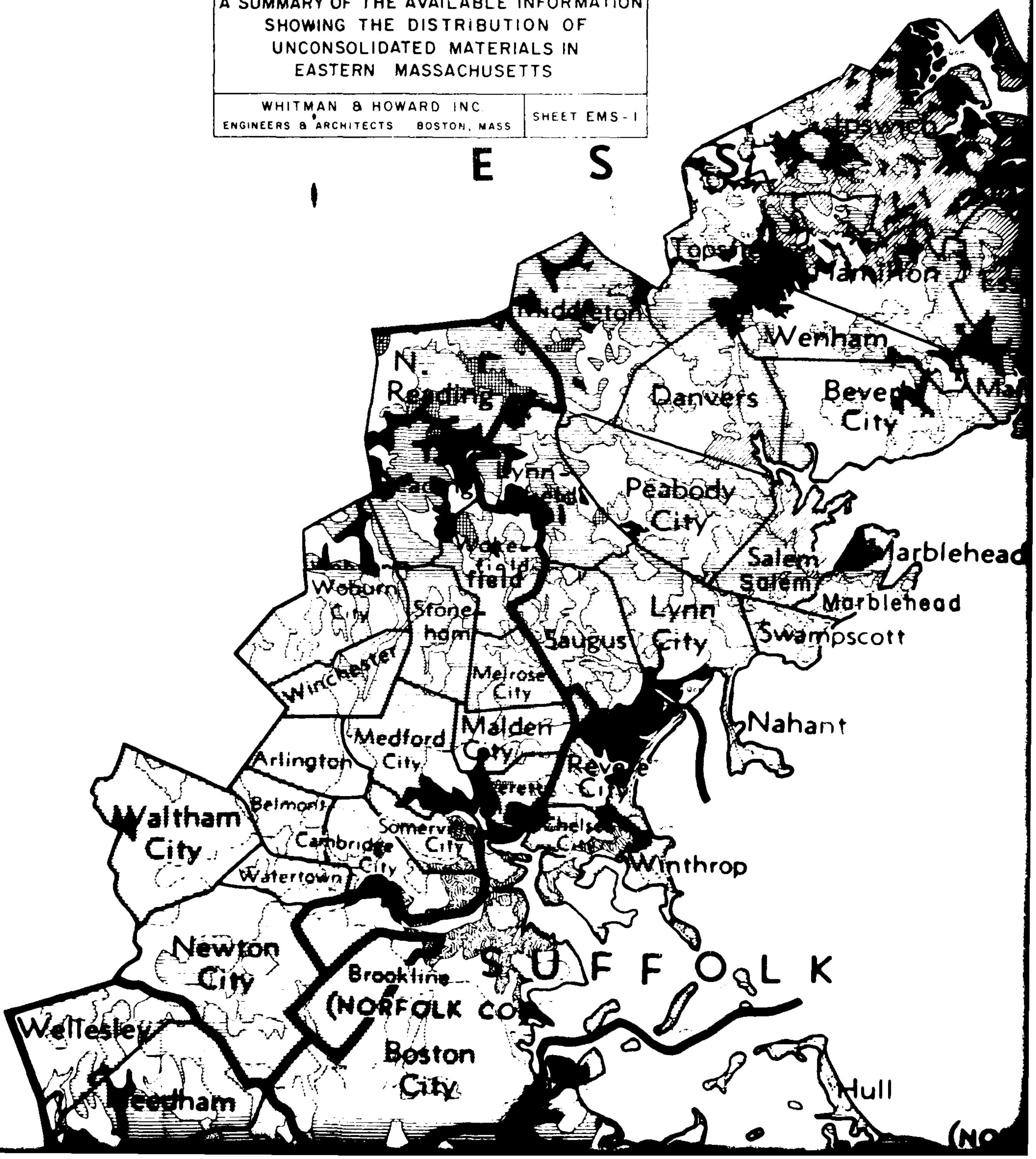
BOSTON HARBOR - EASTERN MASSACHUSETTS
METROPOLITAN AREA WASTE WATER
MANAGEMENT STUDY

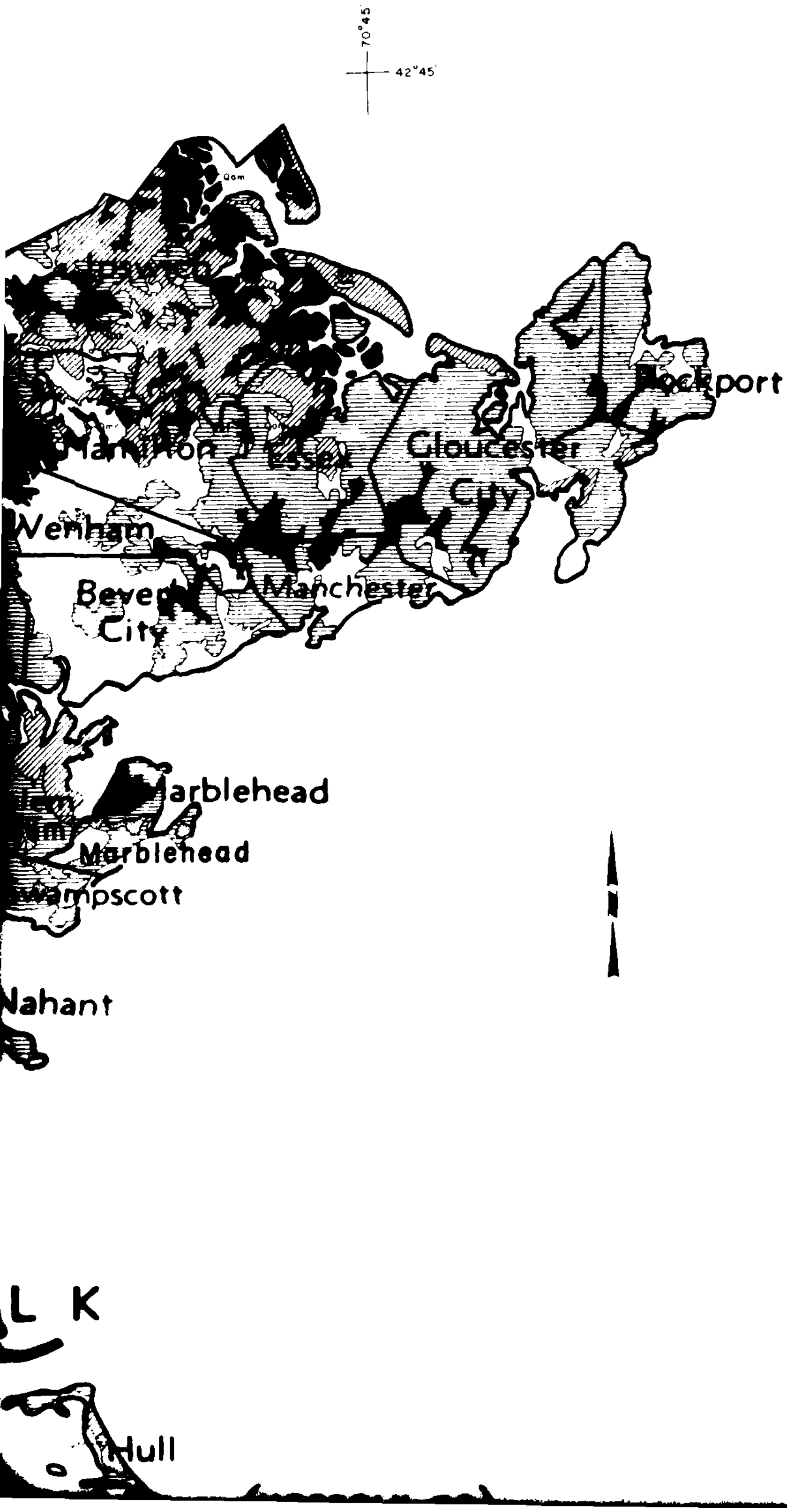
UNITED STATES ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION WALTHAM, MASS

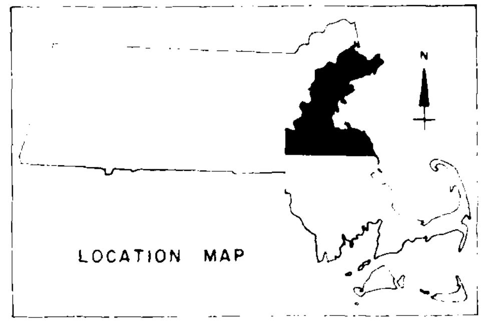
A SUMMARY OF THE AVAILABLE INFORMATION
SHOWING THE DISTRIBUTION OF
UNCONSOLIDATED MATERIALS IN
EASTERN MASSACHUSETTS

WHITMAN & HOWARD INC.
ENGINEERS & ARCHITECTS BOSTON, MASS

SHEET EMS - 1



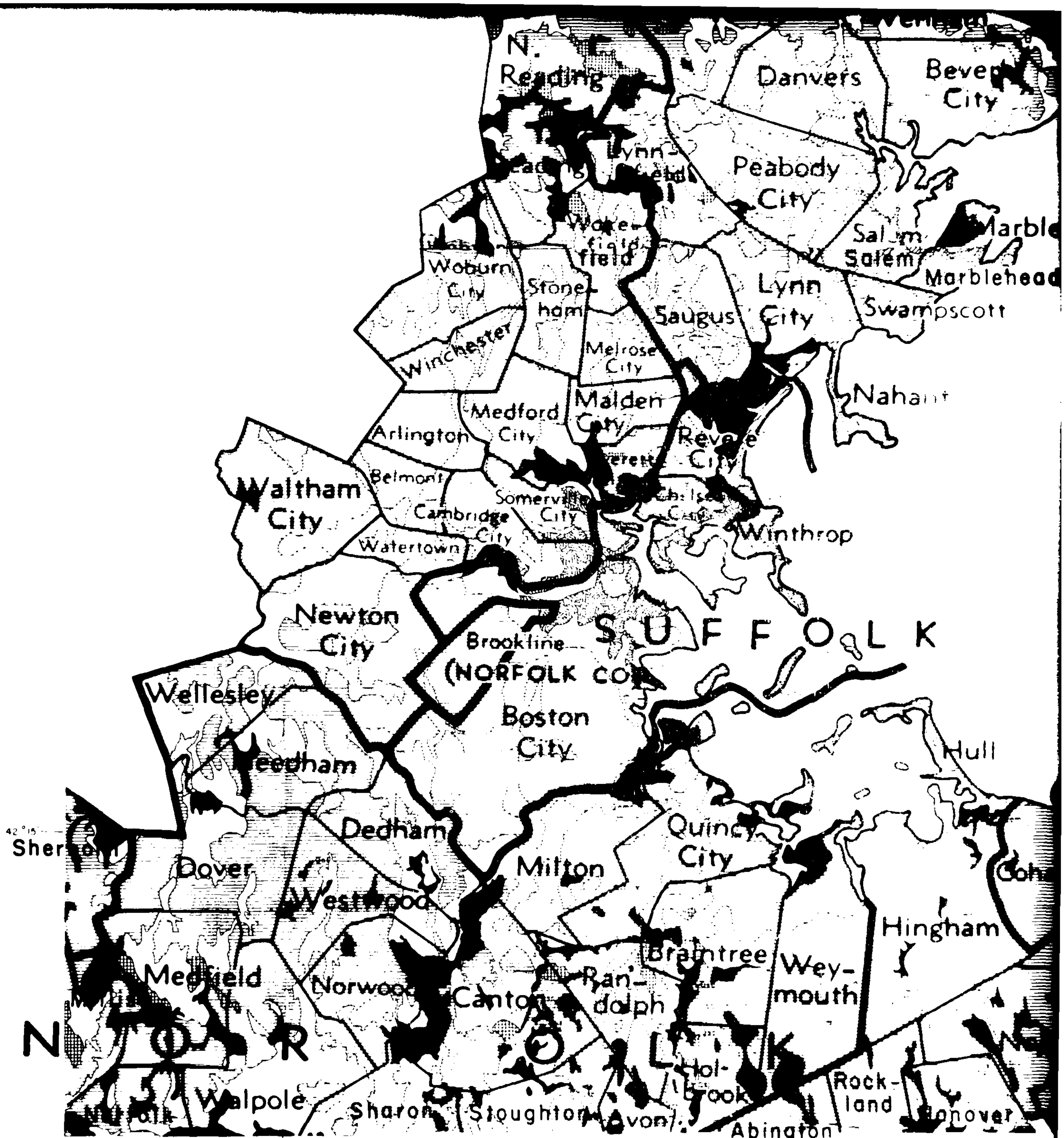




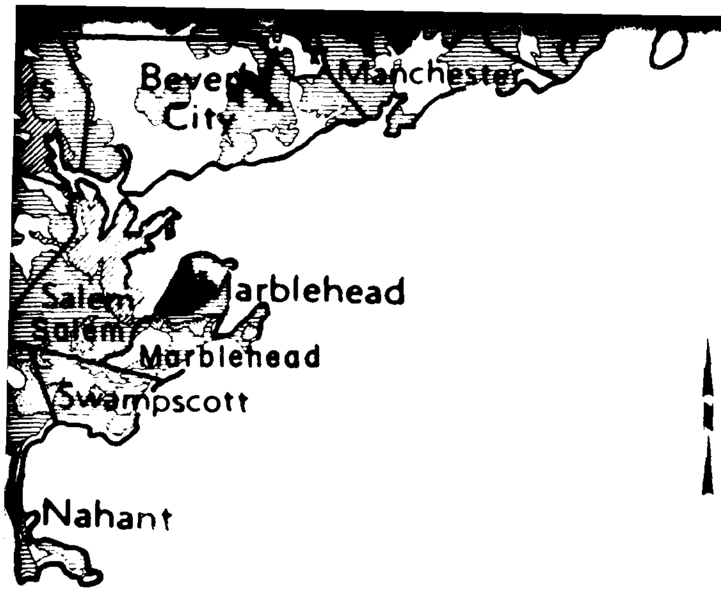
LEGEND

	SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
COARSE GRAINED SOILS	Qsc	OUTWASH AND ICE CONTACT DEPOSITS	SANDS or SANDS and GRAVELS Silt and/or clay portions usually minor - stratified and sorted
	Qmc	BEACH, DUNE AND MARINE DEPOSITS	Fine or Fine to medium SANDS well sorted - often stratified and cross bedded
	Qac	ALLUVIUM AND RIVER TERRACE DEPOSITS	SAND, SILT with minor amounts of Gravel, Clay and/or Organics poorly to moderately sorted and stratified
	Qtc	GLACIAL TILL	Silty or Clayey SAND and GRAVEL with Cobbles and boulders dense, non-stratified unsorted mixture
FINE-GRAINED AND/OR ORGANIC SOILS	Qlf	GLACIAL LAKE BOTTOM DEPOSITS	SILTS, Clayey SILTS, Silty SANDS, Varved Silts and Clays
	Qmf	MARINE DEPOSITS	Silty CLAYS, SILTS and CLAYS SILTS Silty fine SANDS
	Qof	FRESH-WATER ORGANIC DEPOSITS	PEATS, Sandy PEATS, Silty PEATS, Organic Sands and Silts MUCK
	Qom	MARINE ORGANIC DEPOSITS	ORGANIC SILT Clayey Organic Silts, Organic Sands Marsh Mats "Ooze"

ARTIFICIAL FILL



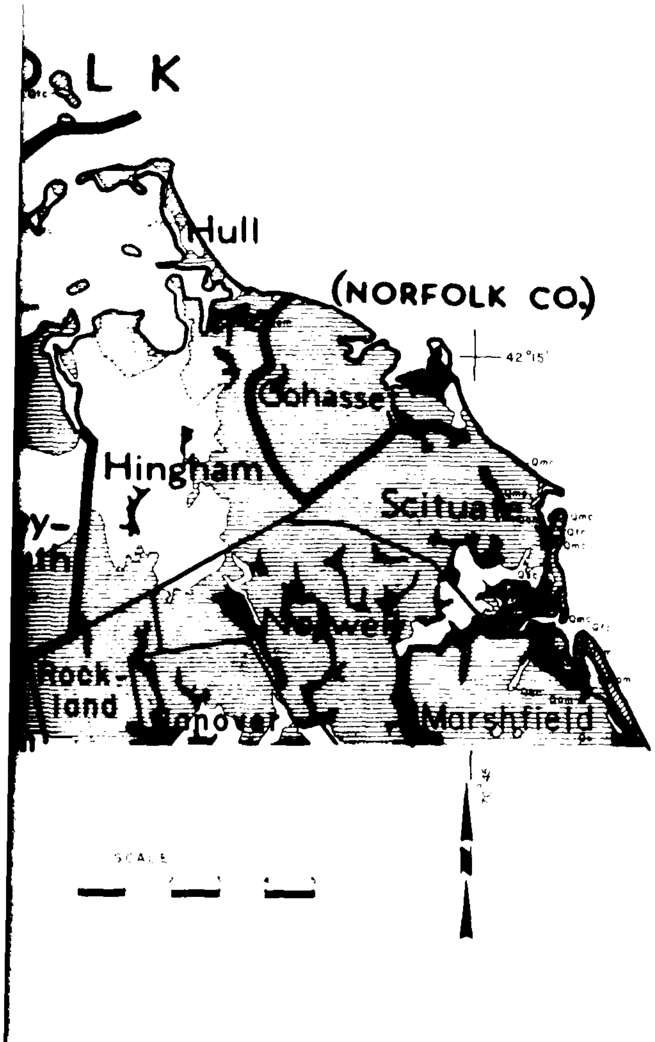
N. Reading
Danvers
Peabody City
Salem
Marblehead
Lynn City
Swampscott
Saugus
Nahant
Woburn City
Stoneham
Winchester
Melrose City
Malden City
Medford City
Arlington
Revere City
Waltham City
Belmont
Somerville City
Cambridge City
Watertown
Winthrop
Newton City
Brookline (NORFOLK CO.)
SUFFOLK
Wellesley
Boston City
Needham
Hull
Dedham
Quincy City
Dover
Milton
Westwood
Hingham
Braintree
Weymouth
Medfield
Norwood
Canton
Randolph
NORFOLK
Walpole
Sharon
Stoughton
Avon
Holbrook
Abington
Rockland
Hanover

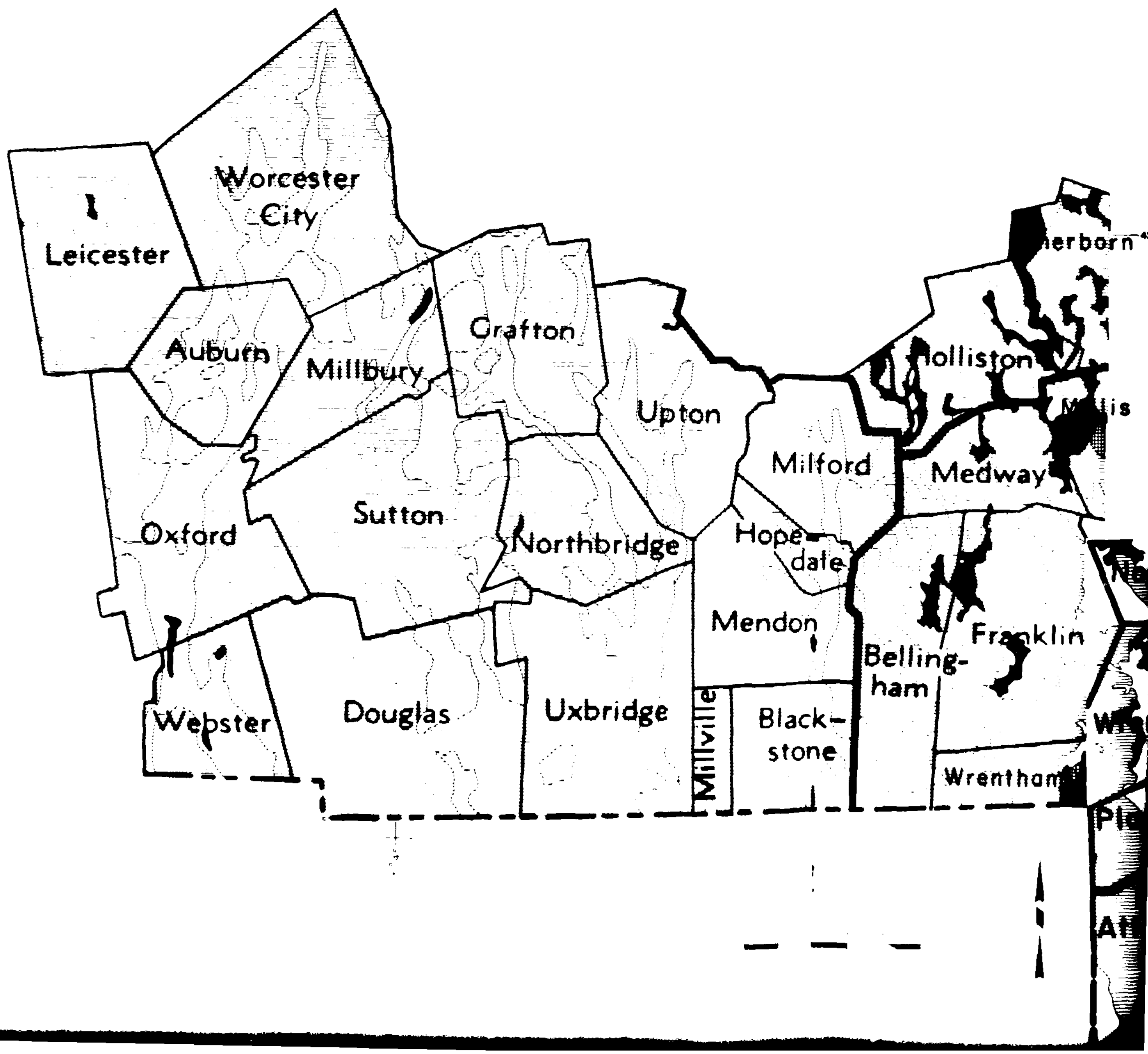


LEGEND

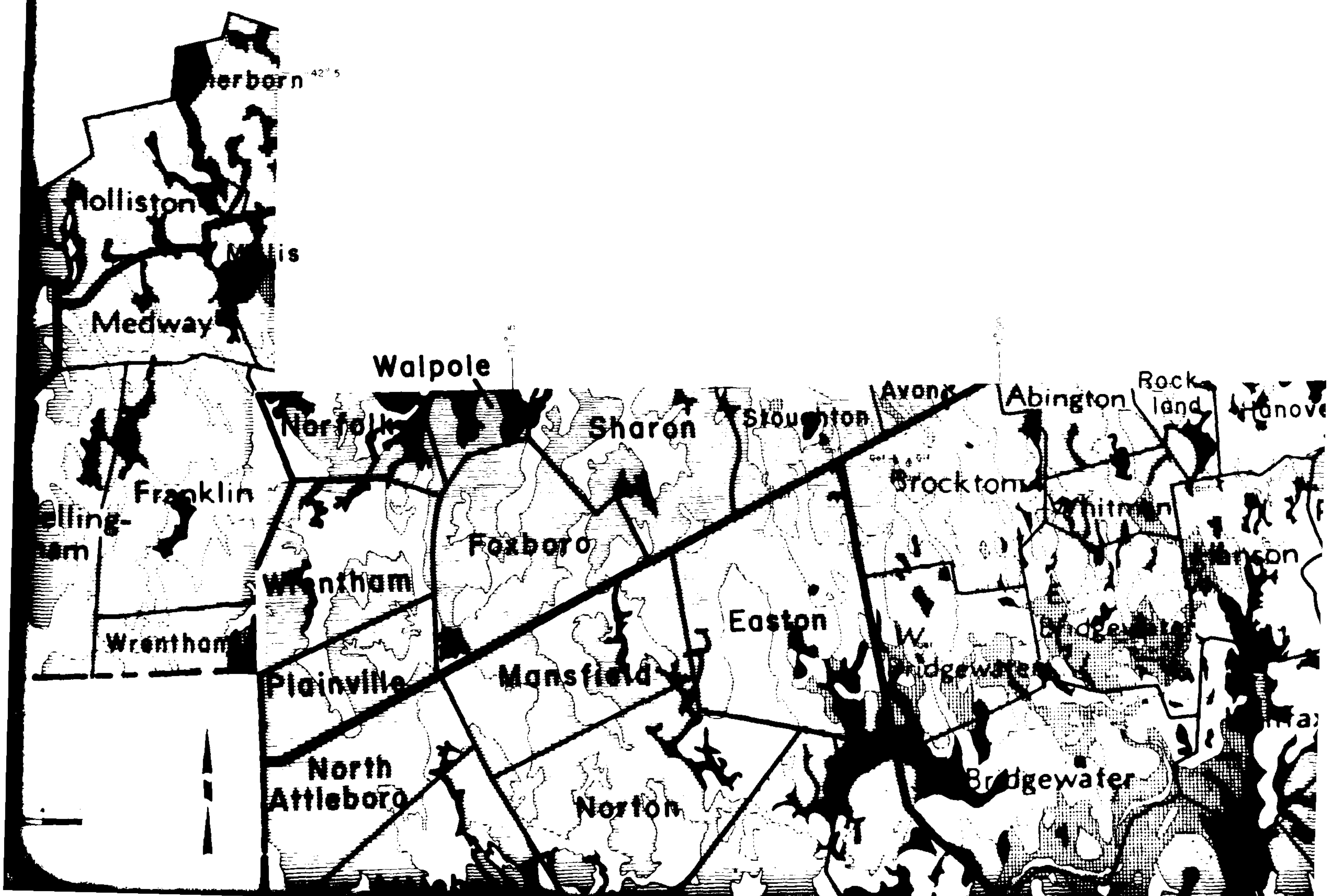
	SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
COARSE GRAINED SOILS	Qsc	OUTWASH AND ICE CONTACT DEPOSITS	SANDS or SANDS and GRAVELS Silt and/or clay portions usually minor, stratified and sorted
	Qm	BEACH, DUNE AND MARINE DEPOSITS	Fine or Fine to medium SANDS well sorted, often stratified and cross bedded
	Qal	ALLUVIUM AND RIVER TERRACE DEPOSITS	SAND, SILT with minor amounts of Gravel, Clay and/or Organics, poorly to moderately sorted and stratified
	Gtc	GLACIAL TILL	Silty or Clayey SAND and GRAVEL with Cobbles and boulders, dense non stratified unsorted mixture
FINE GRAINED AND/OR ORGANIC SOILS	Qlf	GLACIAL LAKE BOTTOM DEPOSITS	SILTS, Clayey SILTS, Silty SANDS, Varved Silts and Clays
	Gmf	MARINE DEPOSITS	Silty CLAYS, SILTS and CLAYS, SILTS, Silty fine SANDS
	Qof	FRESH WATER ORGANIC DEPOSITS	PEATS, Sandy PEATS, Silty PEATS, Organic Sands and Silts, MUCK
	Qom	MARINE ORGANIC DEPOSITS	ORGANIC SILT, Clayey ..., Silts, Organic Sands, Marsh Mats, Peat

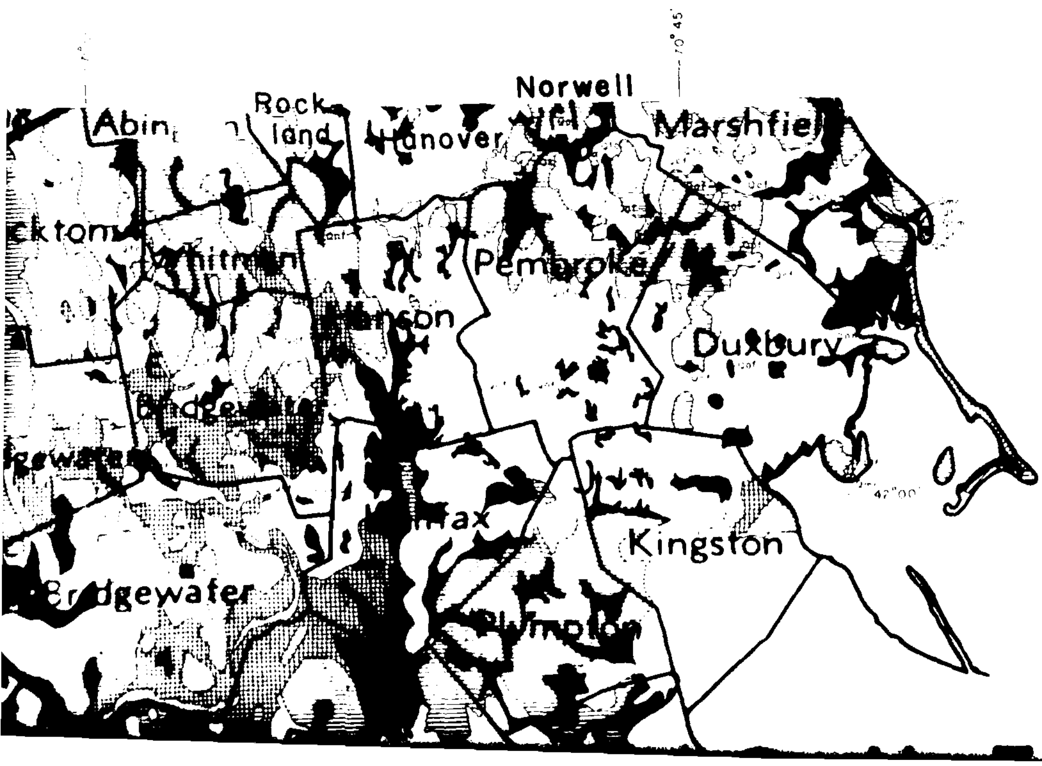
ARTIFICIAL FILL

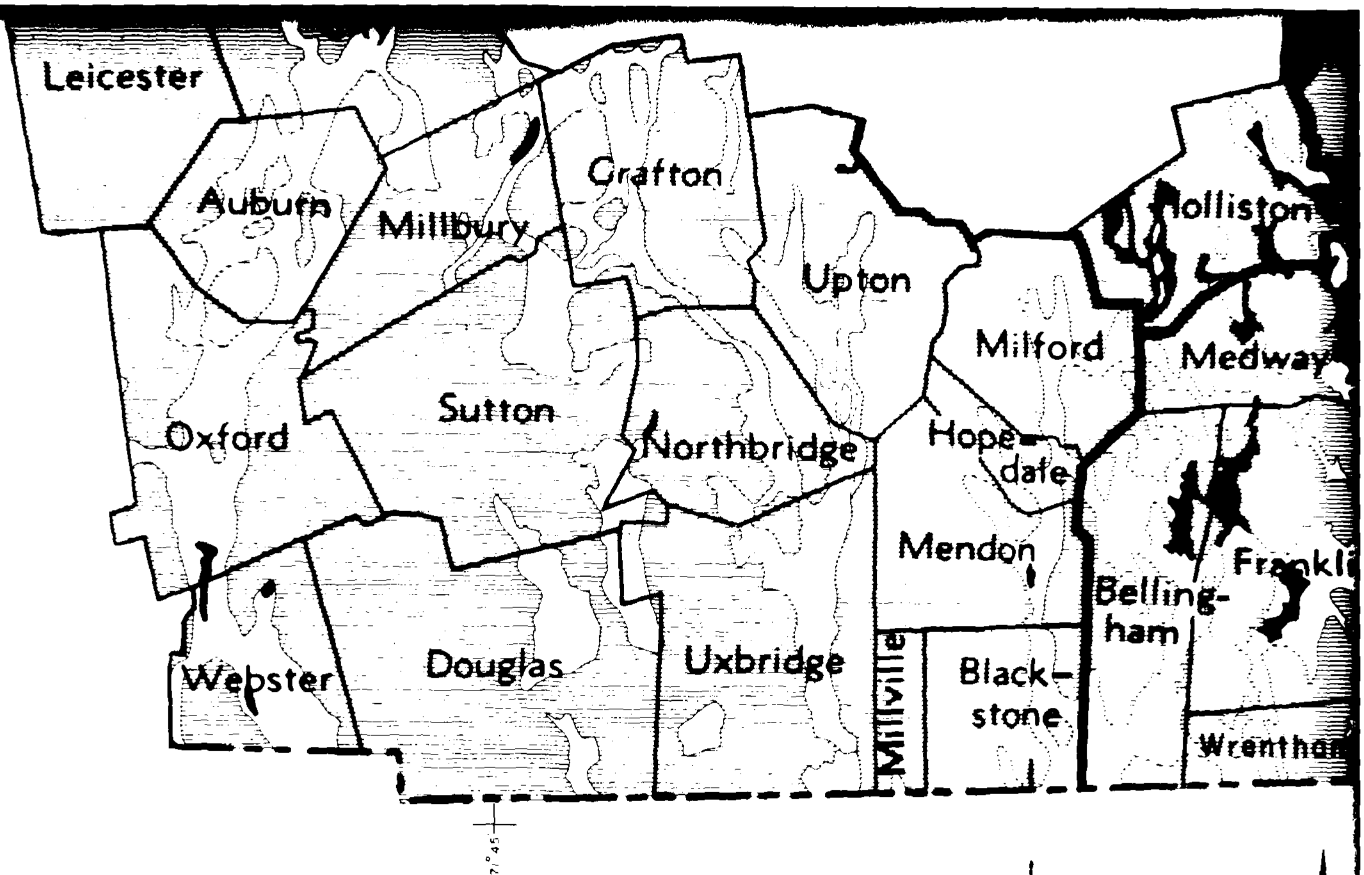




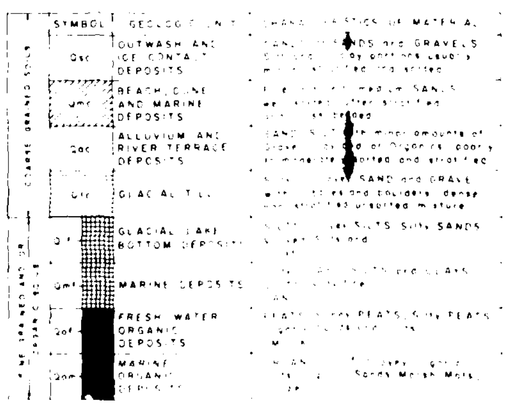
Worcester City
Leicester
Auburn
Millbury
Grafton
Upton
Holliston
Milford
Medway
Oxford
Sutton
Northbridge
Hopedale
Mendon
Franklin
Bellingham
Webster
Douglas
Uxbridge
Millville
Blackstone
Wrentham


Medway
Walpole
Norfolk
Sharon
Avon
Abington
Rock-
land
Franklin
Foxboro
Wrentham
Wrentham
Easton
Plainville
Mansfield
North
Attleboro
Norton
Bridgewater

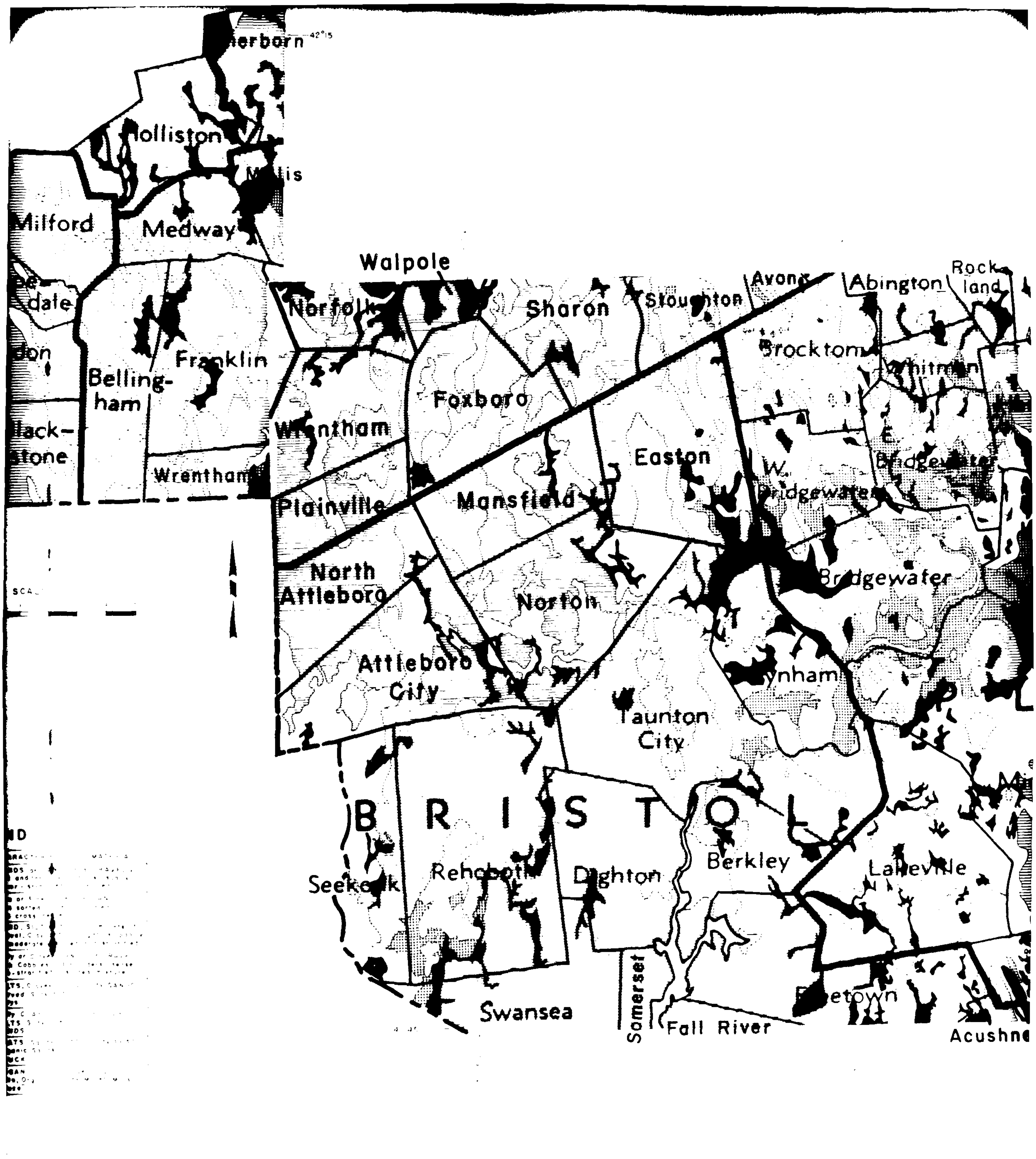

Norwell
Rock-
land
Hanover
Pembroke
Duxbury
Kingston



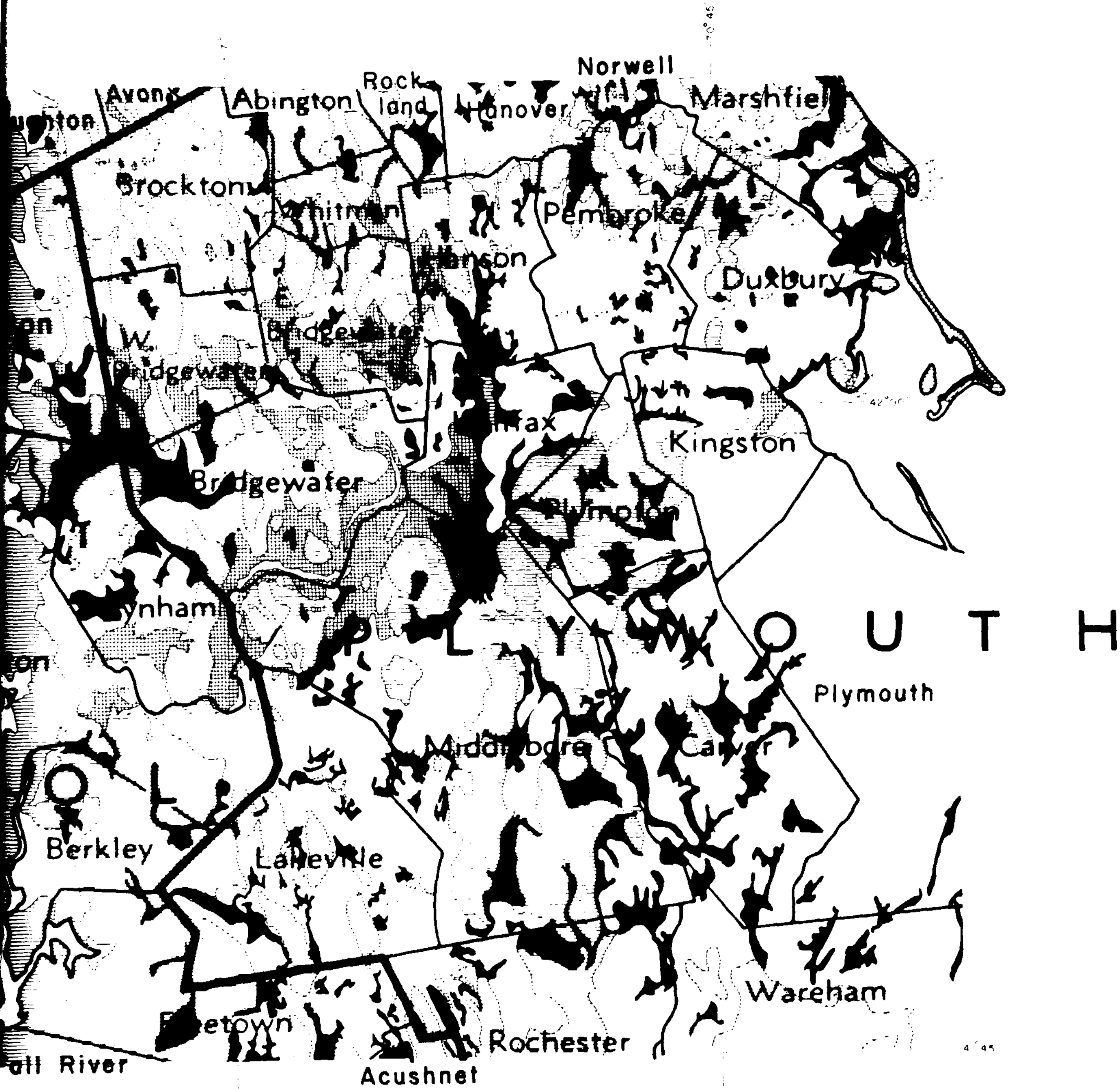
LEGEND



BOSTON HARBOR - EASTERN MASSACHUSETTS METROPOLITAN AREA WASTE WATER MANAGEMENT STUDY
UNITED STATES ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION WALTHAM, MASS
A SUMMARY OF THE AVAILABLE INFORMATION SHOWING THE DISTRIBUTION OF UNCONSOLIDATED MATERIALS IN EASTERN MASSACHUSETTS
WHITMAN & HOWARD INC. ENGINEERS & ARCHITECTS BOSTON, MASS. — SHEET EMS-2



Walpole
Norfolk
Sharon
Stoughton
Avon
Abington
Rock land
Milford
Medway
Franklin
Bellingham
Wrentham
Foxboro
Brockton
Whitman
Plainville
Mansfield
Easton
E. Bridgewater
W. Bridgewater
North Attleboro
Norton
Bridgewater
Attleboro City
Taunton City
BRISTOL
Seekonk
Rehoboth
Dighton
Berkley
Lakeville
Swansea
Somerset
Fall River
Acushne


Norwell
Avon
Abington
Rock-
land
Hanover
Marshfield
Brockton
Whitman
Pembroke
Hanson
Duxbury
W.
Bridgewater
Bridgewater
Halifax
Kingston
Bridgewater
Plympton
Raynham
P L Y M O U T H
Plymouth
Middleboro
Carver
Berkley
Lakeville
Wareham
Freetown
Rochester
Fall River
Acushnet

BOSTON HARBOR - EASTERN MASSACHUSETTS
METROPOLITAN AREA WASTE WATER
MANAGEMENT STUDY

UNITED STATES ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION WALTHAM, MASS.

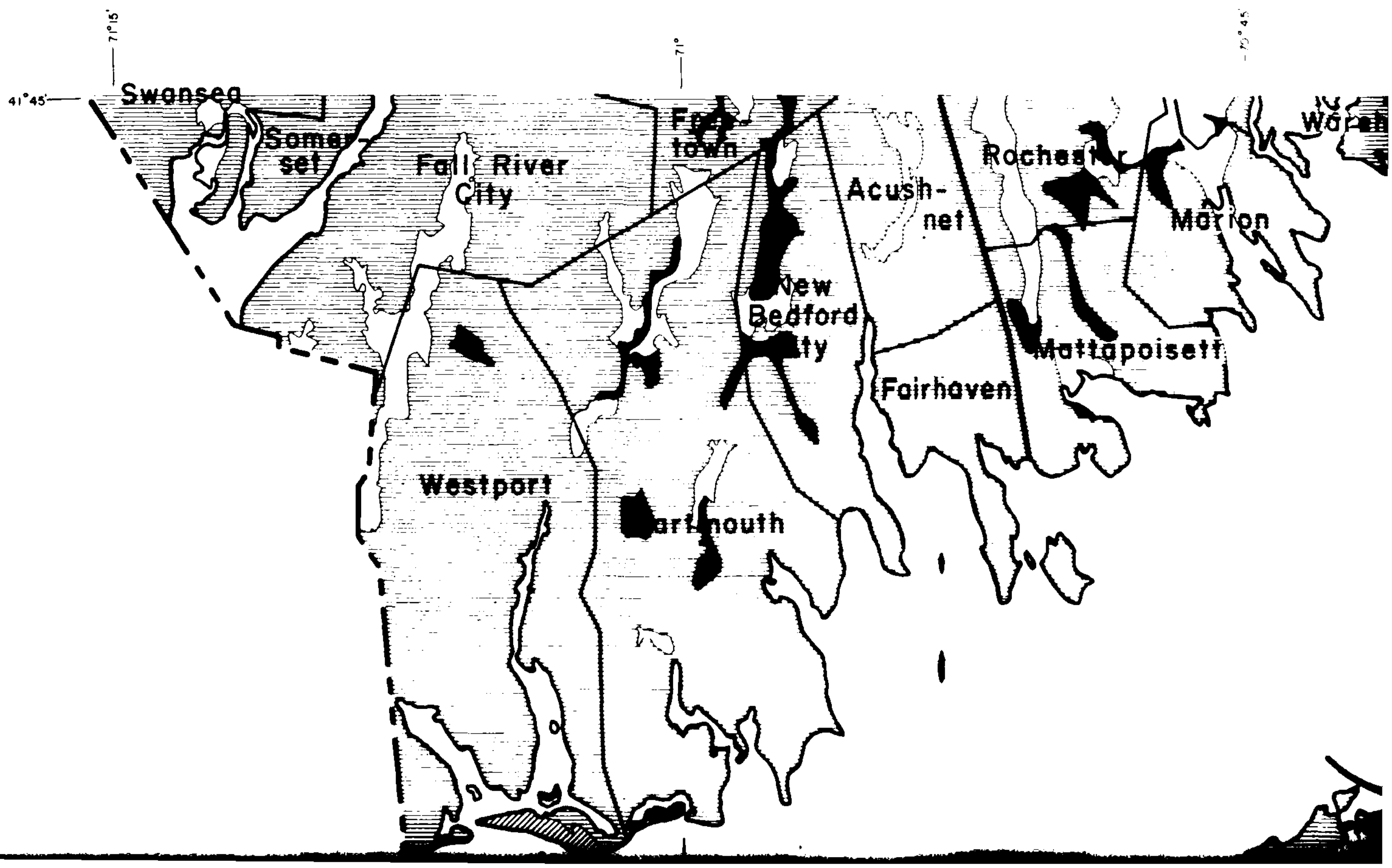
A SUMMARY OF THE AVAILABLE INFORMATION SHOWING THE DISTRIBUTION OF UNCONSOLIDATED MATERIALS IN EASTERN MASSACHUSETTS

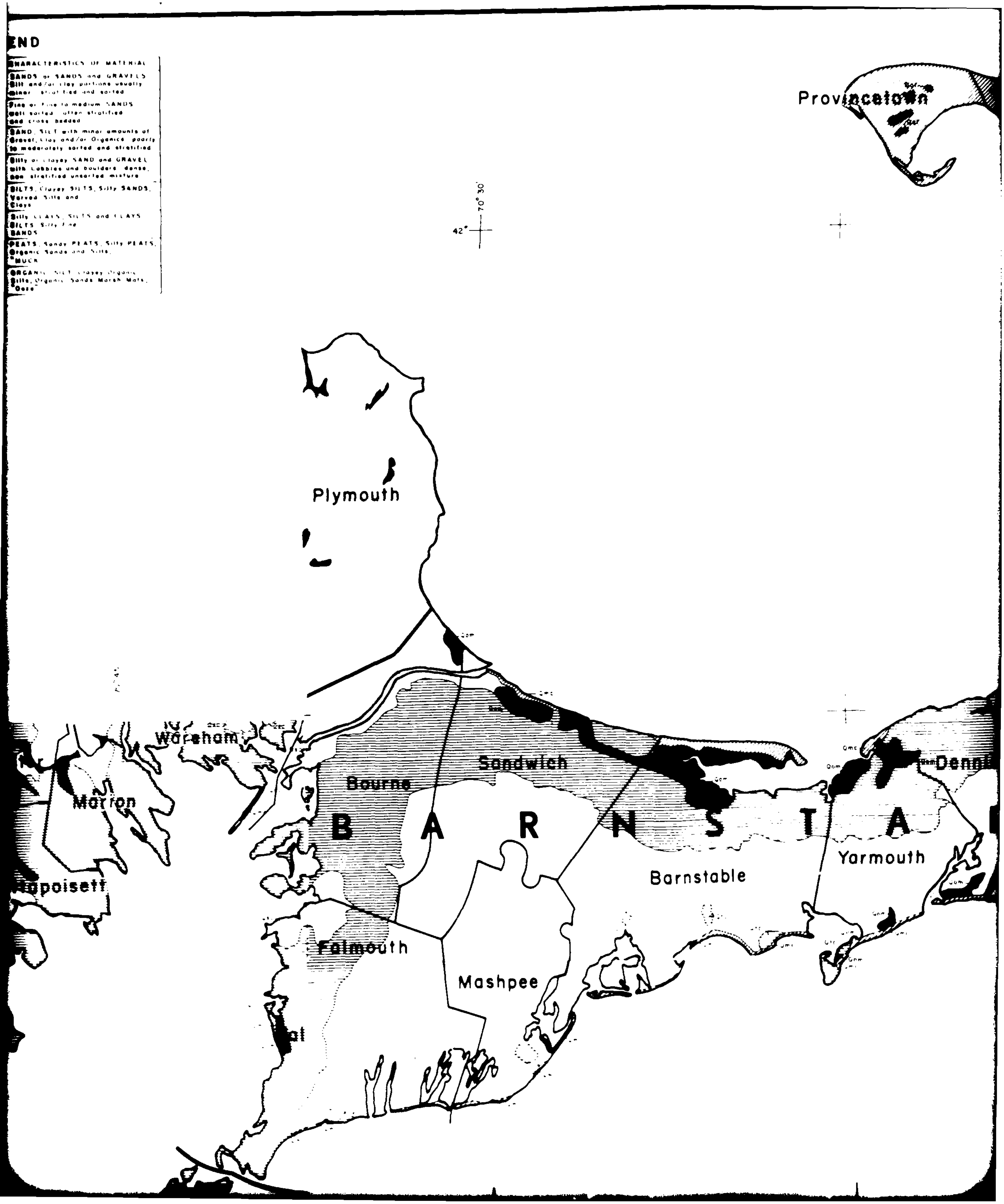
WHITMAN & HOWARD INC.
ENGINEERS & ARCHITECTS BOSTON, MASS.

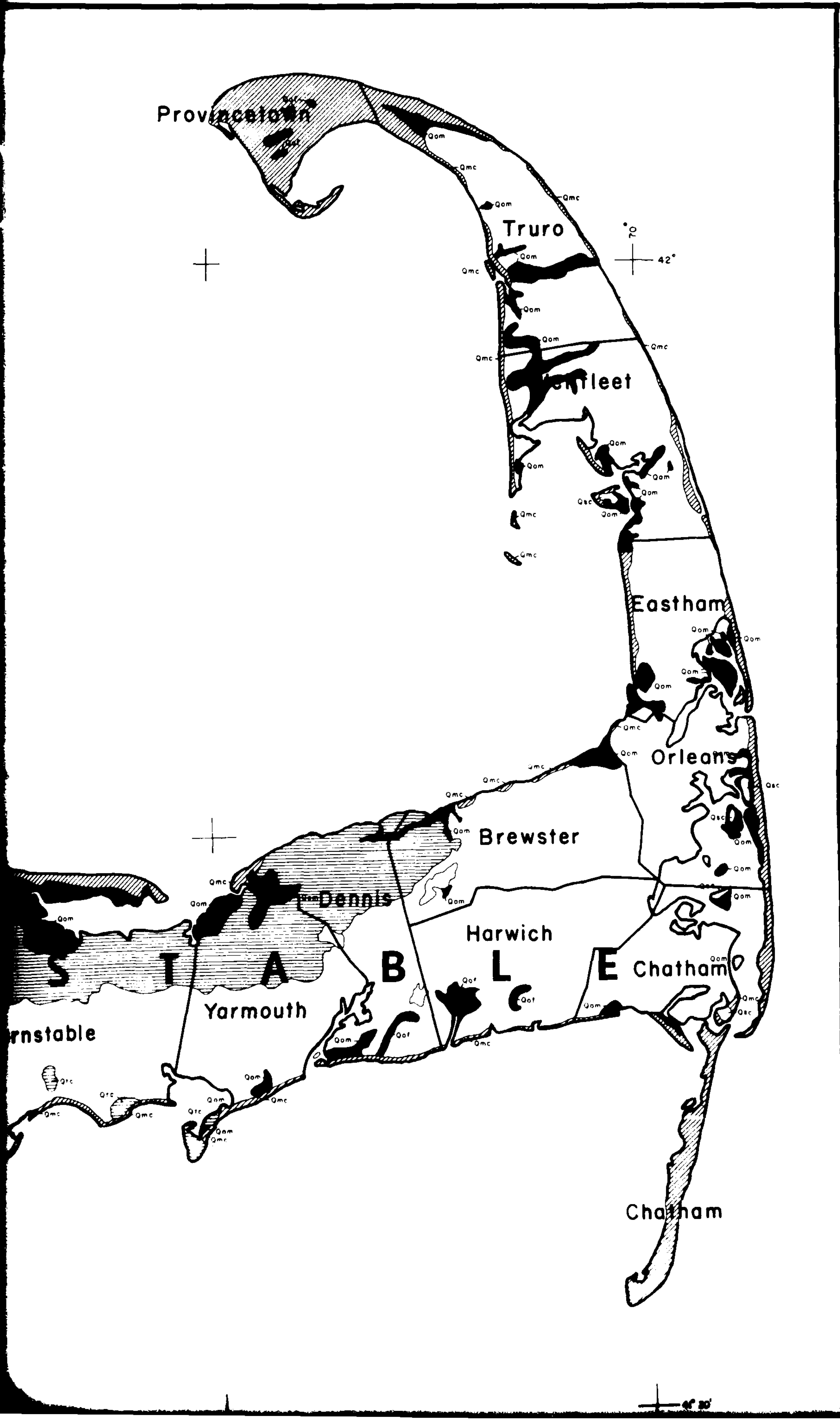
SHEET EMS-3

LEGEND

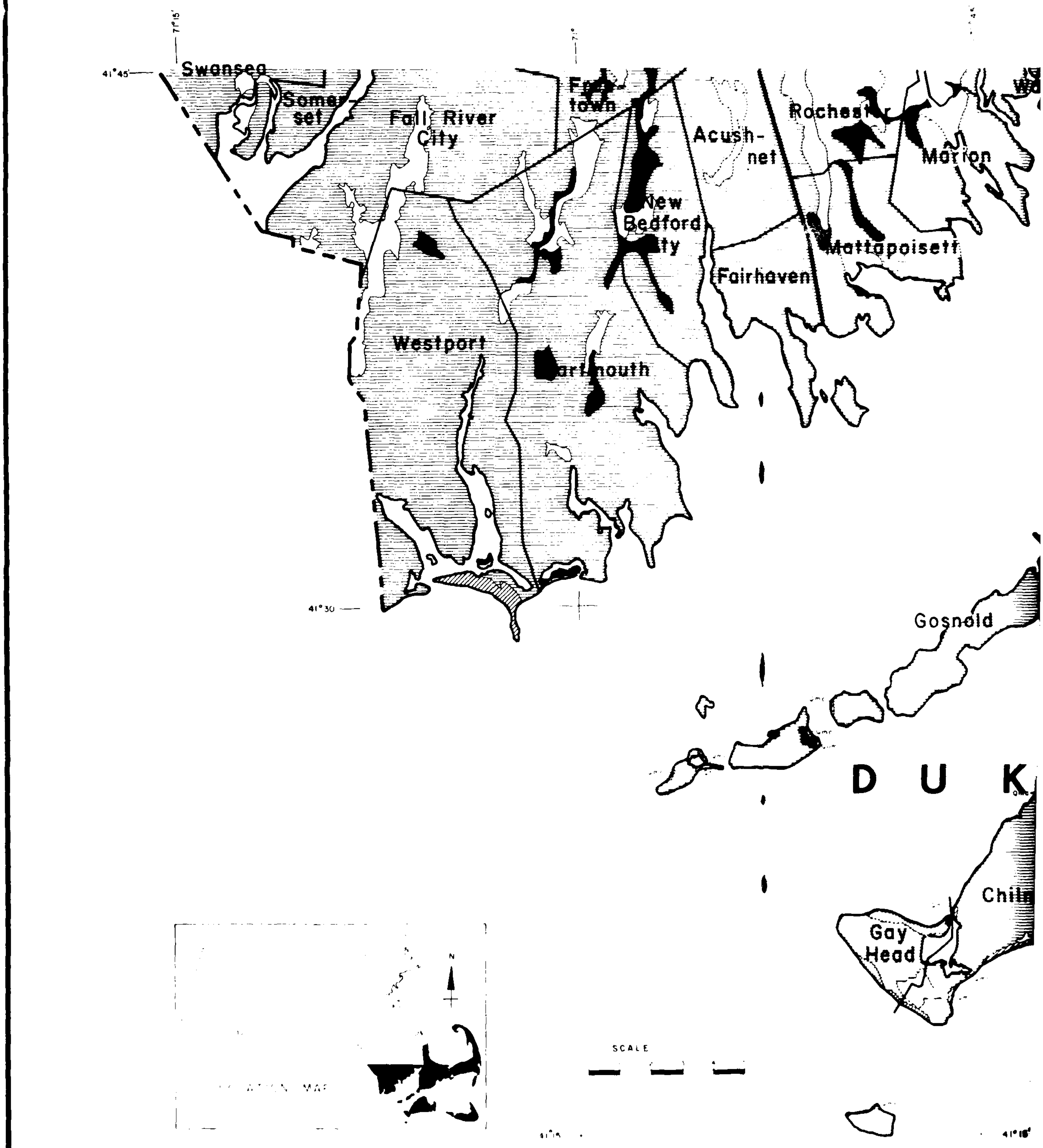
	SYMBOL	GEOLOGIC UNIT	CHARACTERISTICS OF MATERIAL
COARSE GRAINED SOILS	Qsc	OUTWASH AND ICE CONTACT DEPOSITS	SANDS or SANDS and GRAVELS Silt and/or Clay portions usually minor stratified and sorted
	Qmc	BEACH, DUNE AND MARINE DEPOSITS	Fine or Fine to medium SANDS well sorted often stratified and cross bedded
	Qac	ALLUVIUM AND RIVER TERRACE DEPOSITS	SAND SILT with minor amounts of Gravel, Clay and/or Organics poorly to moderately sorted and stratified
	Qtc	GLACIAL TILL	Silty or Clayey SAND and GRAVEL with Cobbles and boulders dense, non stratified unsorted mixture
FINE-GRAINED AND/OR ORGANIC SOILS	Qlf	GLACIAL LAKE BOTTOM DEPOSITS	SILTS, Clayey SILTS, Silty SANDS, Varved Silts and Clays
	Qmf	MARINE DEPOSITS	Silty CLAYS, SILTS and CLAYS SILTS Silty fine SANDS
	Qof	FRESH-WATER ORGANIC DEPOSITS	PEATS, Sandy PEATS Silty PEATS Organic Sands and Silts MUCK
	Qom	MARINE ORGANIC DEPOSITS	ORGANIC SILT Clayey Organic Silts, Organic Sands Marsh Mats "Ooze"



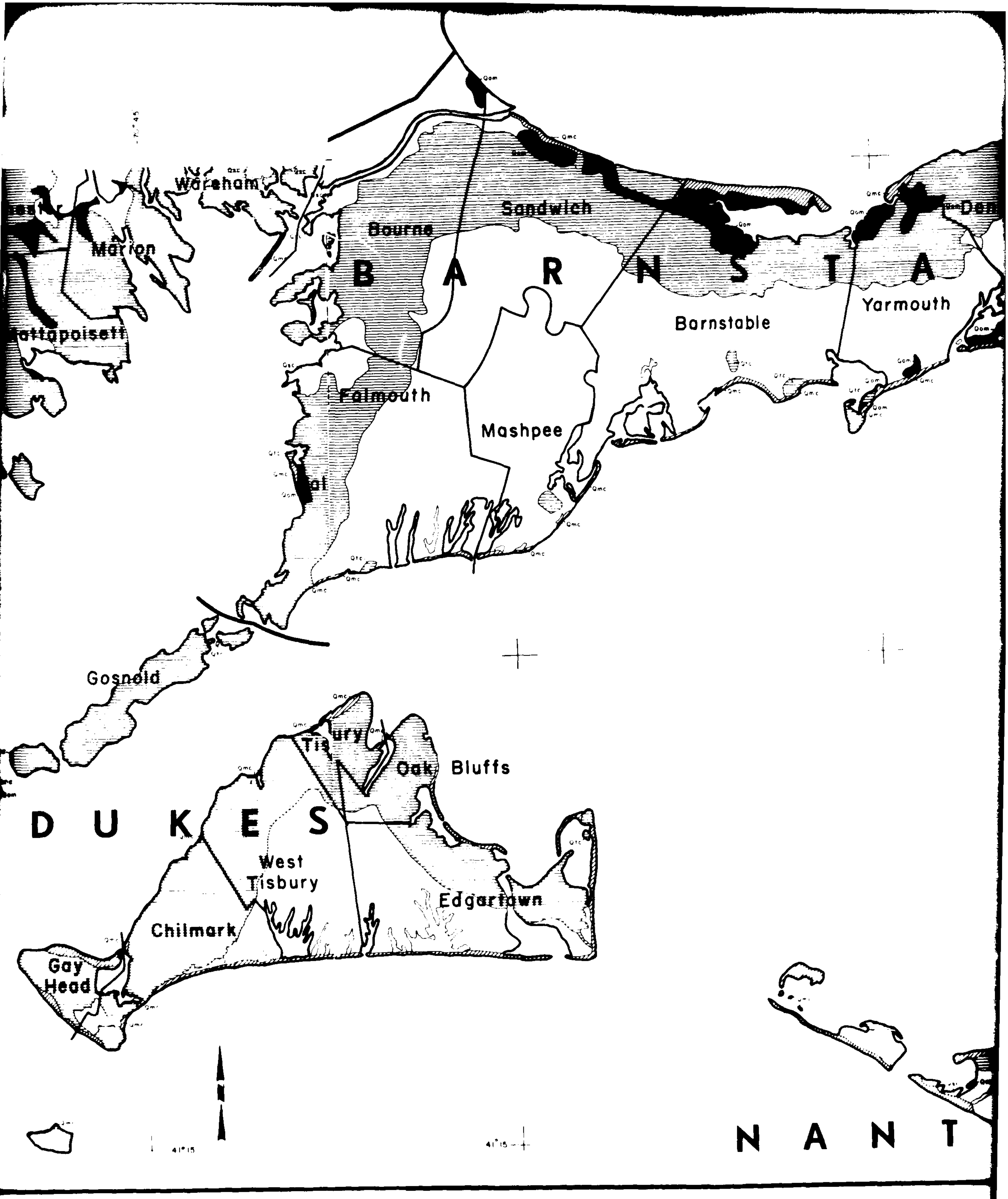

END
CHARACTERISTICS OF MATERIAL
SANDS or SANDS and GRAVELS Silt and/or clay portions usually minor stratified and sorted
Fine or Fine to medium SANDS well sorted often stratified and cross bedded
SAND, SILT with minor amounts of Gravel, Clay and/or Organics poorly to moderately sorted and stratified
Silty or clayey SAND and GRAVEL with cobbles and boulders dense, non stratified unsorted mixture
SILTS, Clayey SILTS, Silty SANDS, Varved Silts and Clays
Silty CLAYS, SILTS and CLAYS
SILTS Silty Fine SANDS
PEATS, Sandy PEATS, Silty PEATS, Organic Sands and Silts, "MUCK"
ORGANIC SILT clayey Organic Silts, Organic Sands Marsh Mats, "Ooze"
Provincetown
70° 30'
42°
Plymouth
Wareham
Marion
Mattapoisett
Sandwich
Bourne
B A R N S T A
Dennis
Yarmouth
Barnstable
Falmouth
Mashpee

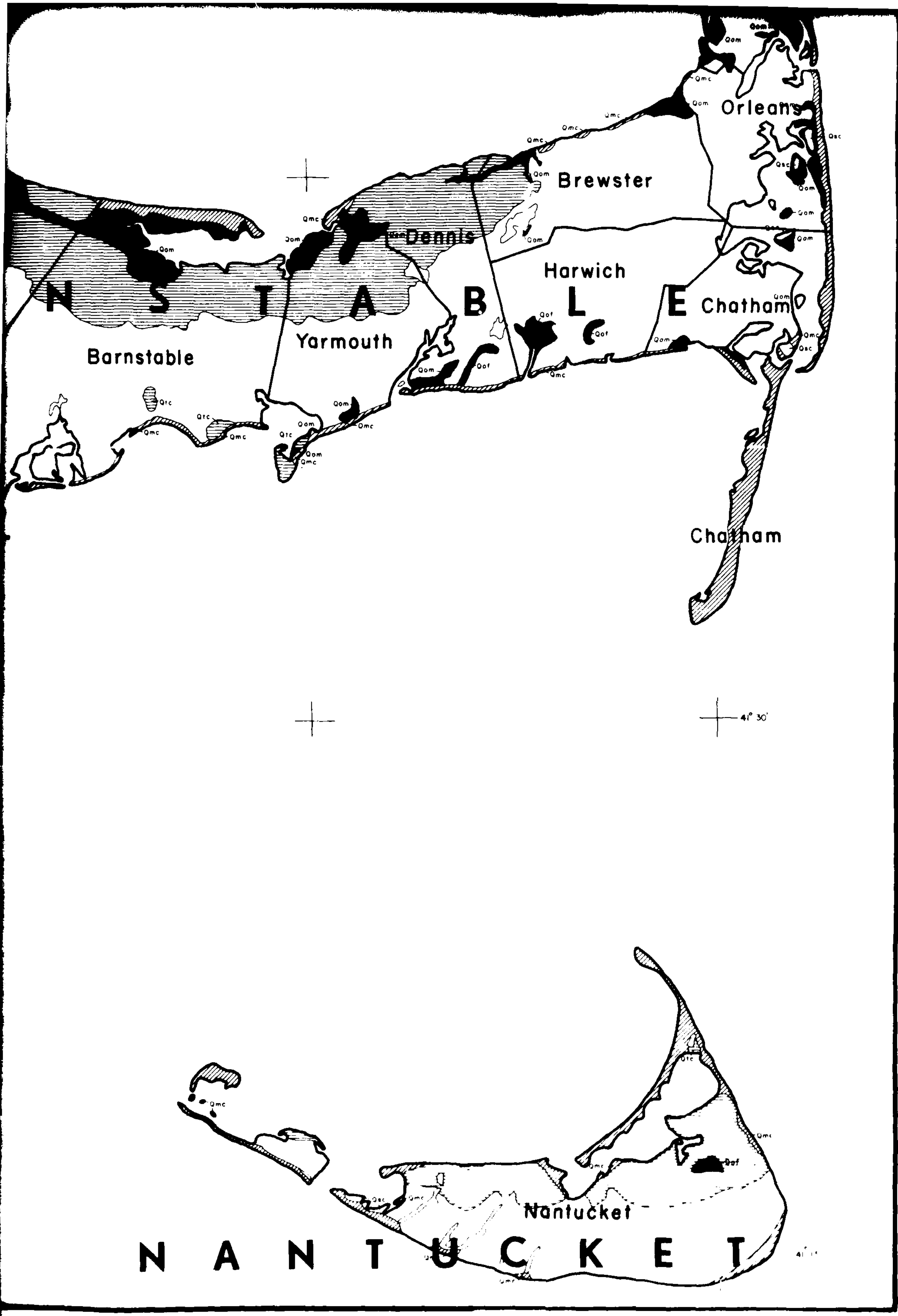


Provincetown
Truro
Wellfleet
Eastham
Orleans
Brewster
Dennis
Harwich
Chatham
Yarmouth
rnstable
S T A B L E
Chatham
42°
70°



41°45'
71°15'
71°
Swansea
Somerset
Fall River City
Free-town
Acushnet
Rochester
Marion
New Bedford City
Mattapoisett
Fairhaven
Westport
Dartmouth
41°30
Gosnold
D U K
Chil
Gay Head
SCALE
N


Wareham
Marion
Mattapoisett
Bourne
Sandwich
B A R N S T A
Yarmouth
Barnstable
Falmouth
Mashpee
Gosnold
Tisbury
Oak Bluffs
D U K E S
West Tisbury
Edgartown
Chilmark
Gay Head
N A N T
41°15


Orleans
Brewster
Dennis
Harwich
N S T A B L E
Chatham
Yarmouth
Barnstable
Chatham
41° 30'
Nantucket
N A N T U C K E T

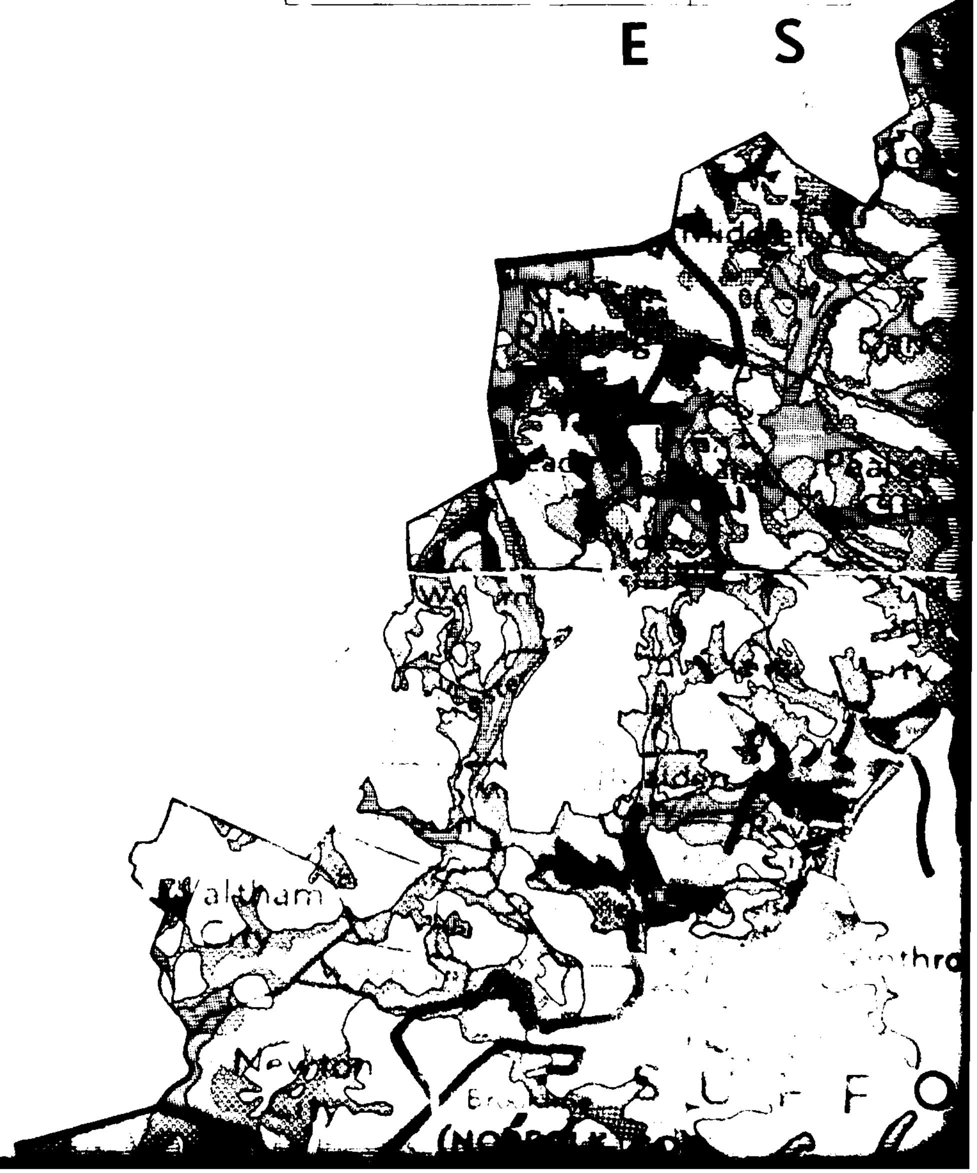
BOSTON HARBOR - EASTERN MASSACHUSETTS
METROPOLITAN AREA WASTE WATER
MANAGEMENT STUDY

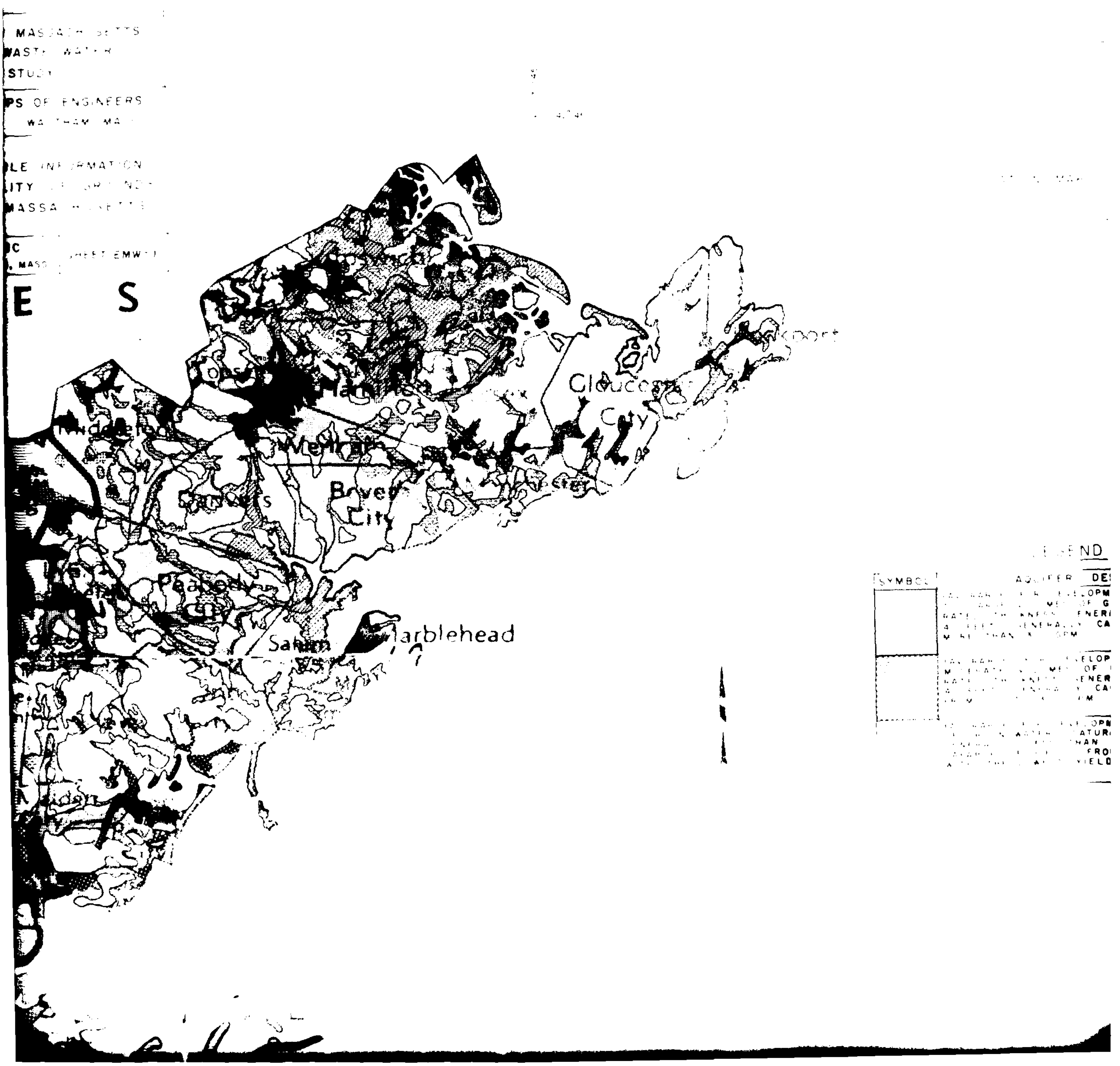
UNITED STATES ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION WALTHAM MASS

A SUMMARY OF AVAILABLE INFORMATION
SHOWING THE FAVORABILITY OF GROUND-
WATER IN EASTERN MASSACHUSETTS

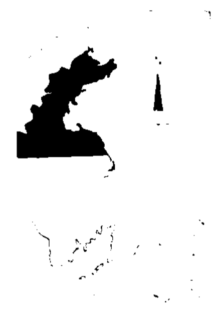
WHITMAN & HOWARD INC
ENGINEERS & ARCHITECTS BOSTON, MASS

SHEET EMW-1

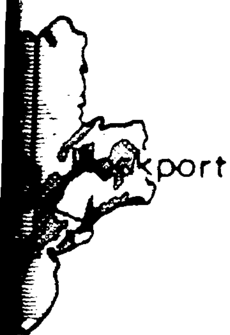




STUDY
PS OF ENGINEERS
E S
Wenham
Danvers
Beverly City
Peabody City
Salem
Marblehead
Gloucester City
SYMBOL
AQUIFER

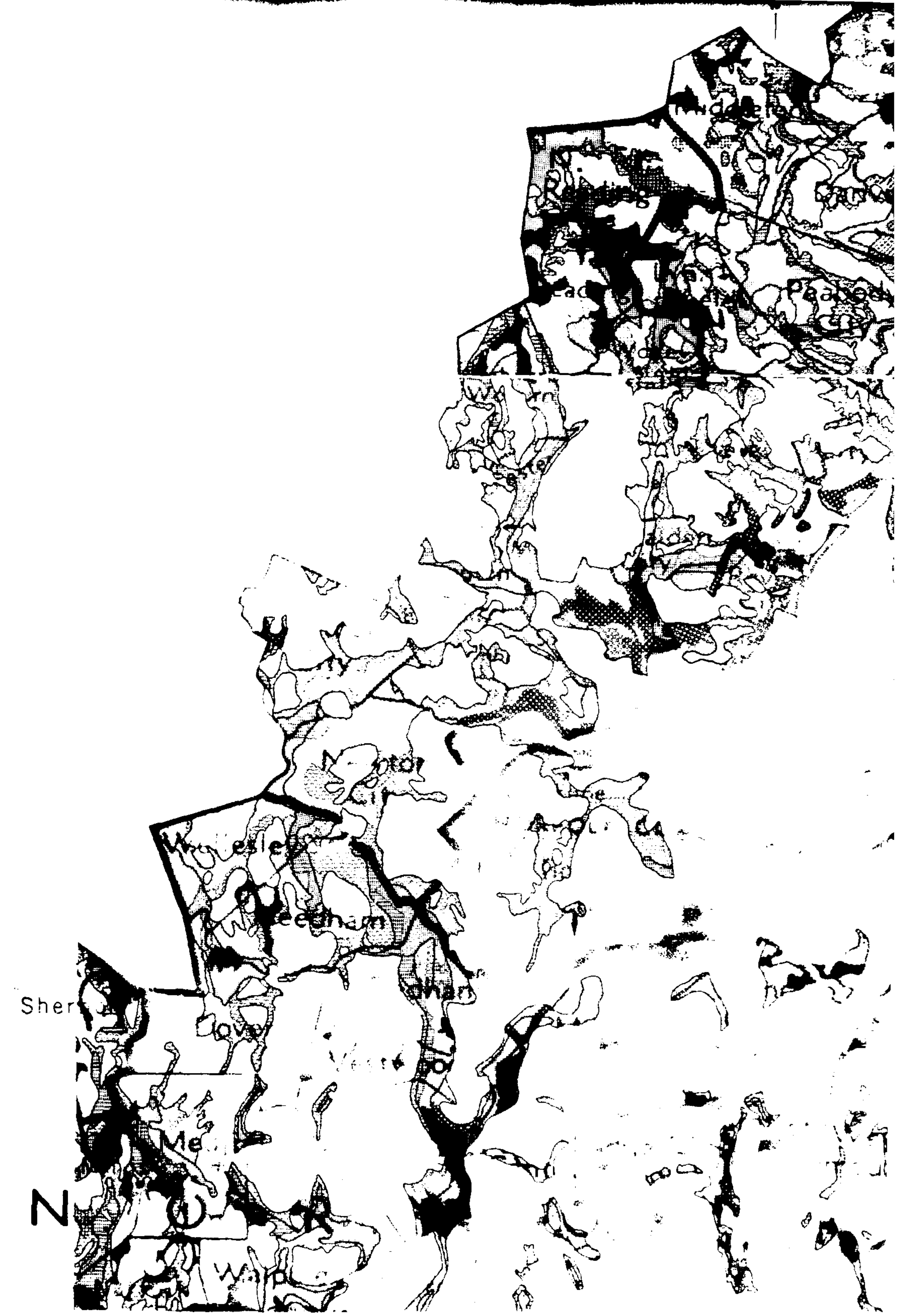


LOCATION MAP



LEGEND

SYMBOL	AQUIFER DESCRIPTION
	FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LARGER THAN 40 FEET; GENERALLY CAPABLE OF YIELDING MORE THAN 300 GPM
	FAVORABLE FOR DEVELOPMENT OF LOW TO MODERATE VOLUMES OF GROUNDWATER, SATURATED THICKNESS GENERALLY FROM 20 TO 40 FEET, GENERALLY CAPABLE OF YIELDS FROM 100 TO 300 GPM
	FAVORABLE FOR DEVELOPMENT OF LOW VOLUMES OF GROUNDWATER, SATURATED THICKNESS GENERALLY LESS THAN 20 FEET, GENERALLY CAPABLE OF YIELDS FROM 0 TO 100 GPM WITH THE LOWEST YIELDS IN TILL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AD-A099 241 CORPS OF ENGINEERS WALTHAM MA NEW ENGLAND DIV F/G 8/7
A SUMMARY OF THE GEOLOGY OF EASTERN MASSACHUSETTS.(U)
JUL 75 F W FESSENDEN, J AYERS, S L DEAN

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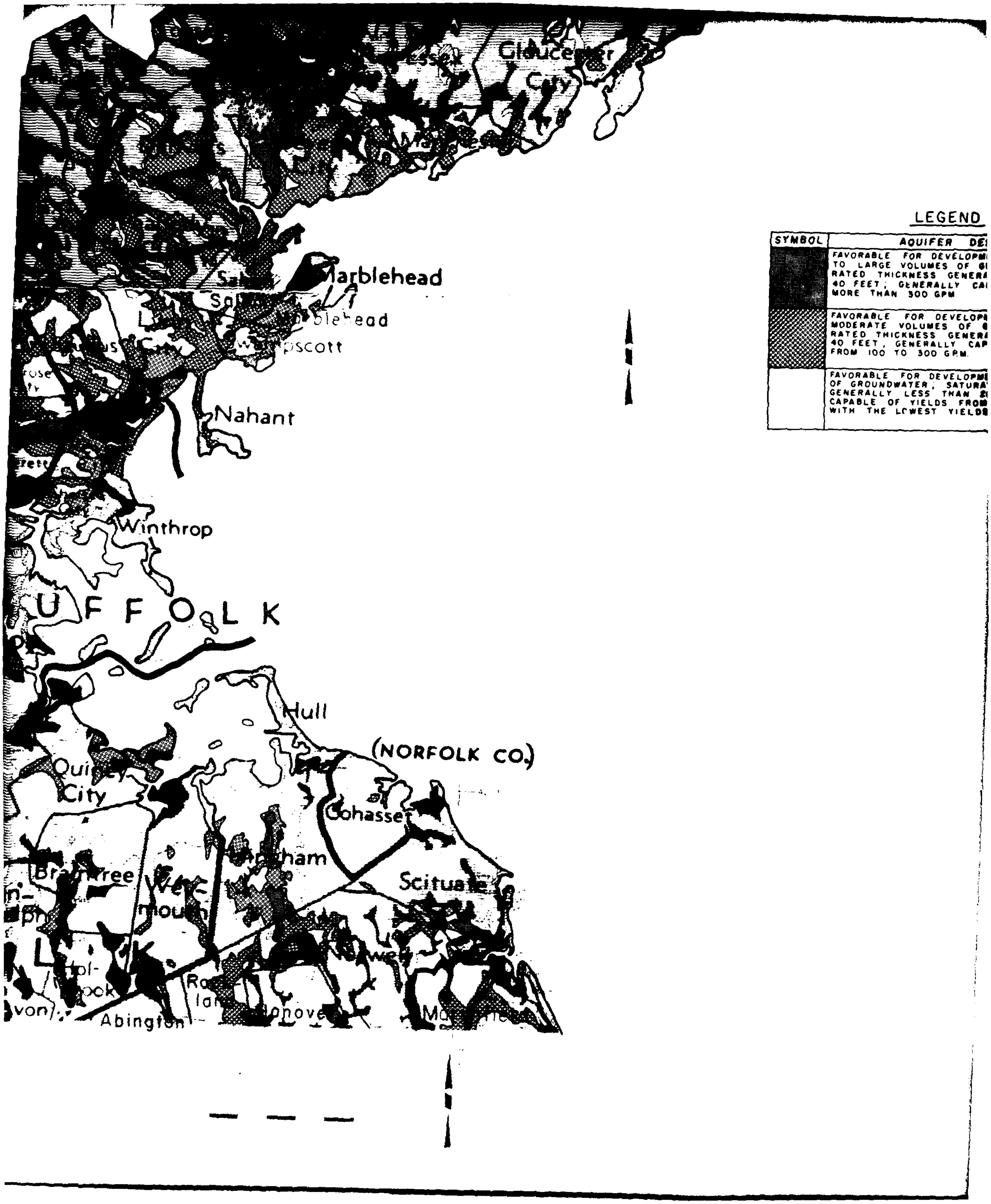

City
Marblehead
Nahant
Winthrop
Hull
(NORFOLK CO.)
City
Scituate
LEGEND
SYMBOL
FAVORABLE FOR DEVELOPM
TO LARGE VOLUMES OF G
RATED THICKNESS GENERA
40 FEET, GENERALLY CA
MORE THAN 300 GPM
FAVORABLE FOR DEVELOP
MODERATE VOLUMES OF
RATED THICKNESS GENER
40 FEET, GENERALLY CAP
FROM 100 TO 300 GPM.
FAVORABLE FOR DEVELOPM
OF GROUNDWATER, SATURA
GENERALLY LESS THAN
CAPABLE OF YIELDS FROM
WITH THE LOWEST YIELD

LEGEND

SYMBOL	AQUIFER DESCRIPTION
	FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LARGER THAN 40 FEET; GENERALLY CAPABLE OF YIELDING MORE THAN 300 GPM
	FAVORABLE FOR DEVELOPMENT OF LOW TO MODERATE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY FROM 20 TO 40 FEET; GENERALLY CAPABLE OF YIELDS FROM 100 TO 300 G.P.M.
	FAVORABLE FOR DEVELOPMENT OF LOW VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LESS THAN 20 FEET; GENERALLY CAPABLE OF YIELDS FROM 0 TO 100 G.P.M. WITH THE LOWEST YIELDS IN TILL

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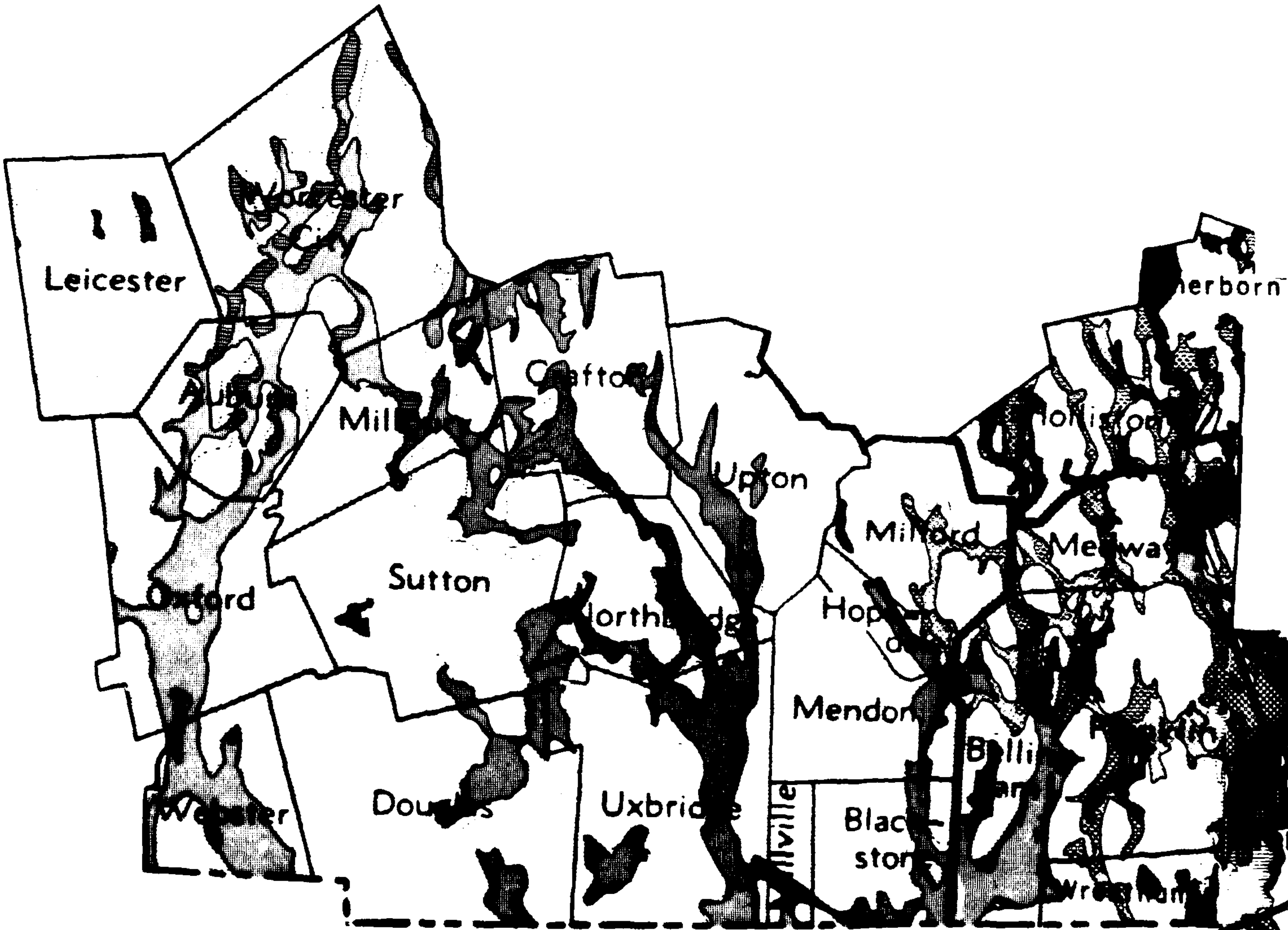
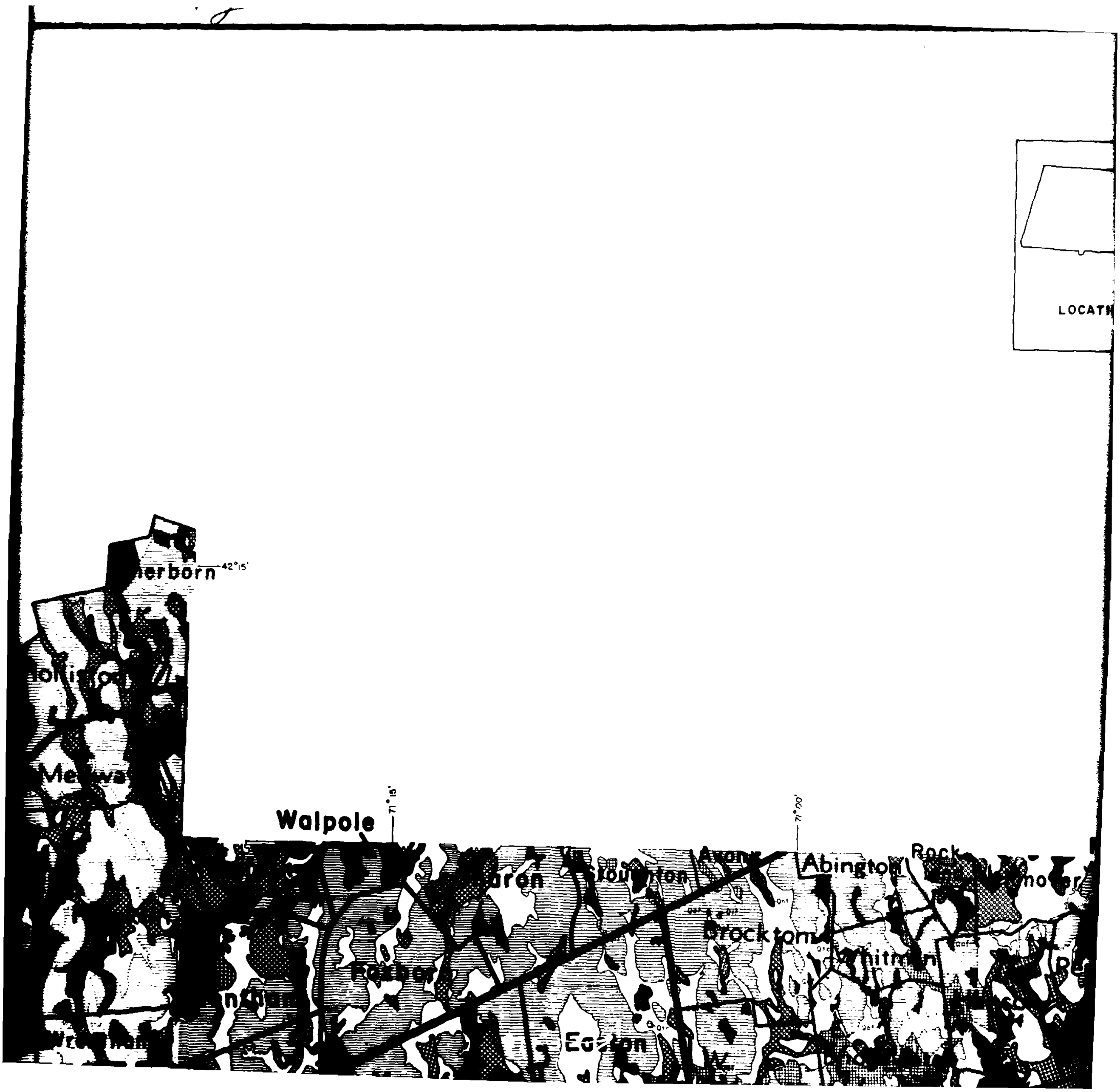
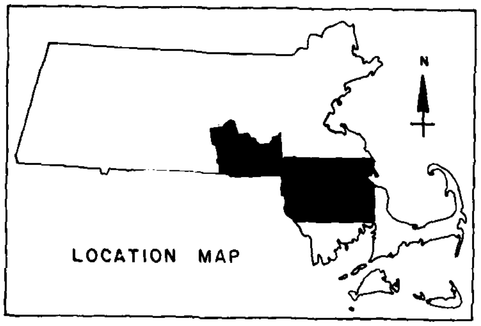

Leicester
Sutton
Upton
Oxford
Mendon
Uxbridge
Milford
Blackstone


42°15'
Walpole
71°15'
71°00'
Abington
Brockton

13



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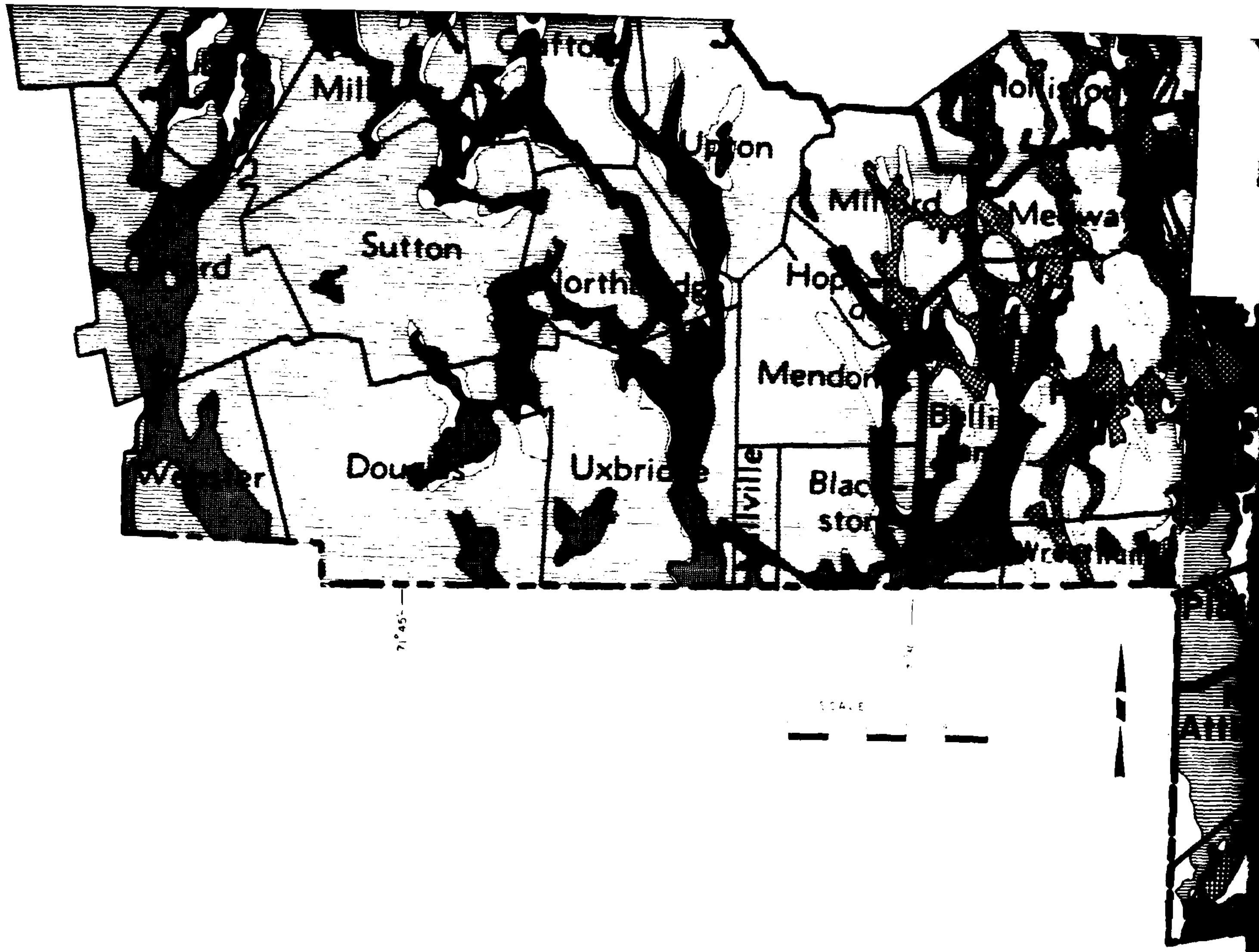


BOSTON HARBOR - EASTERN MASSACHUSETTS
METROPOLITAN AREA WASTE WATER
MANAGEMENT STUDY

UNITED STATES ARMY CORPS OF ENGINEERS
NEW ENGLAND DIVISION WALTHAM, MASS.

A SUMMARY OF AVAILABLE INFORMATION SHOWING THE FAVORABILITY OF GROUND-WATER IN EASTERN MASSACHUSETTS

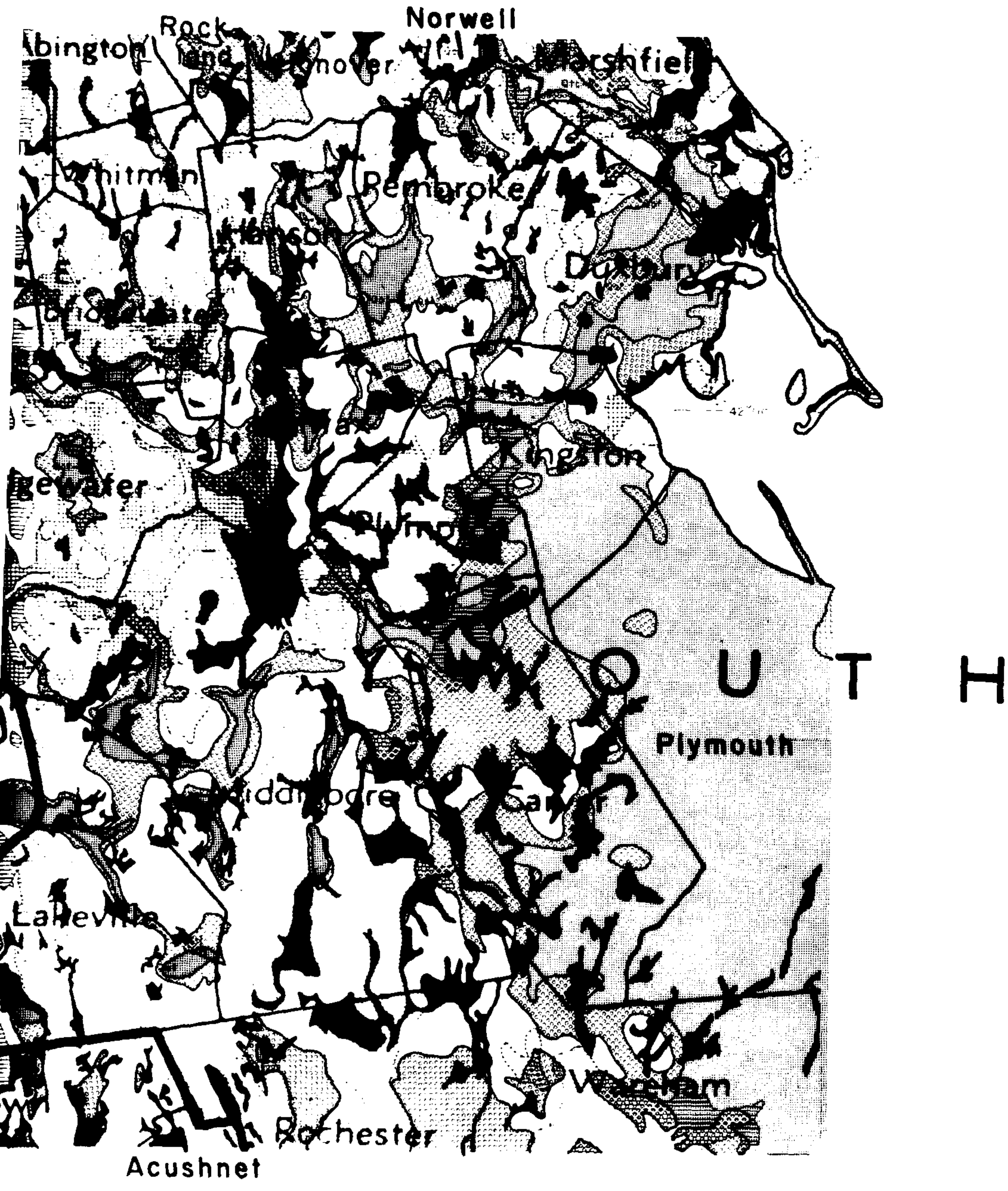
WHITMAN & HOWARD INC.
ENGINEERS & ARCHITECTS BOSTON, MASS

SHEET EMW-2

LEGEND

SYMBOL	AQUIFER DESCRIPTION
	FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LARGER THAN 40 FEET; GENERALLY CAPABLE OF YIELDING MORE THAN 300 GPM
	FAVORABLE FOR DEVELOPMENT OF LOW TO MODERATE VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY FROM 20 TO 40 FEET; GENERALLY CAPABLE OF YIELDS FROM 100 TO 300 GPM
	FAVORABLE FOR DEVELOPMENT OF LOW VOLUMES OF GROUNDWATER; SATURATED THICKNESS GENERALLY LESS THAN 20 FEET, GENERALLY CAPABLE OF YIELDS FROM 0 TO 100 GPM WITH THE LOWEST YIELDS IN TILL


Walpole
Avon
Abington
Brockton
Foxboro
Easton
North Attleboro
Norton
Taunton City
B R I S T O L
Rehoboth
Berkley
Swansea
Somerset
Fall River
Acushnet


Norwell
Marshfiel
Whitman
Pembroke
Kingston
O U T H
Plymouth
Rochester
Acushnet

BOSTON HARBOR - EASTERN MASSACHUSETTS METROPOLITAN AREA WASTE WATER MANAGEMENT STUDY
UNITED STATES ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION WALTHAM, MASS.
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WHITMAN & HOWARD INC. ENGINEERS & ARCHITECTS BOSTON, MASS. — SHEET EMW-3

LEGEND

SYMBOL	AQUIFER DESCRIPTION
	FAVORABLE FOR DEVELOPMENT OF MODERATE TO LARGE VOLUMES OF GROUNDWATER, SATURATED THICKNESS GENERALLY LARGER THAN 40 FEET, GENERALLY CAPABLE OF YIELDING MORE THAN 300 GPM
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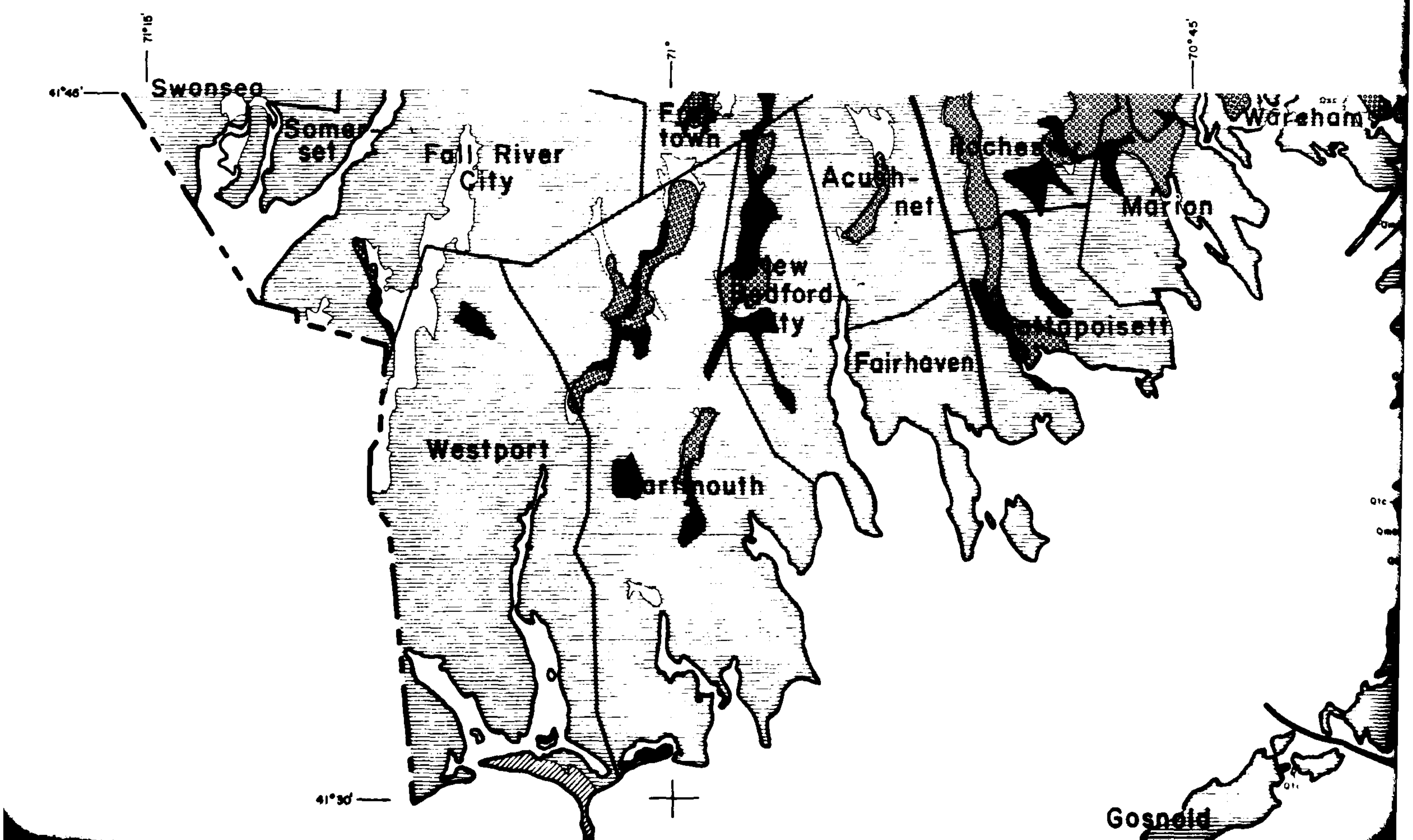
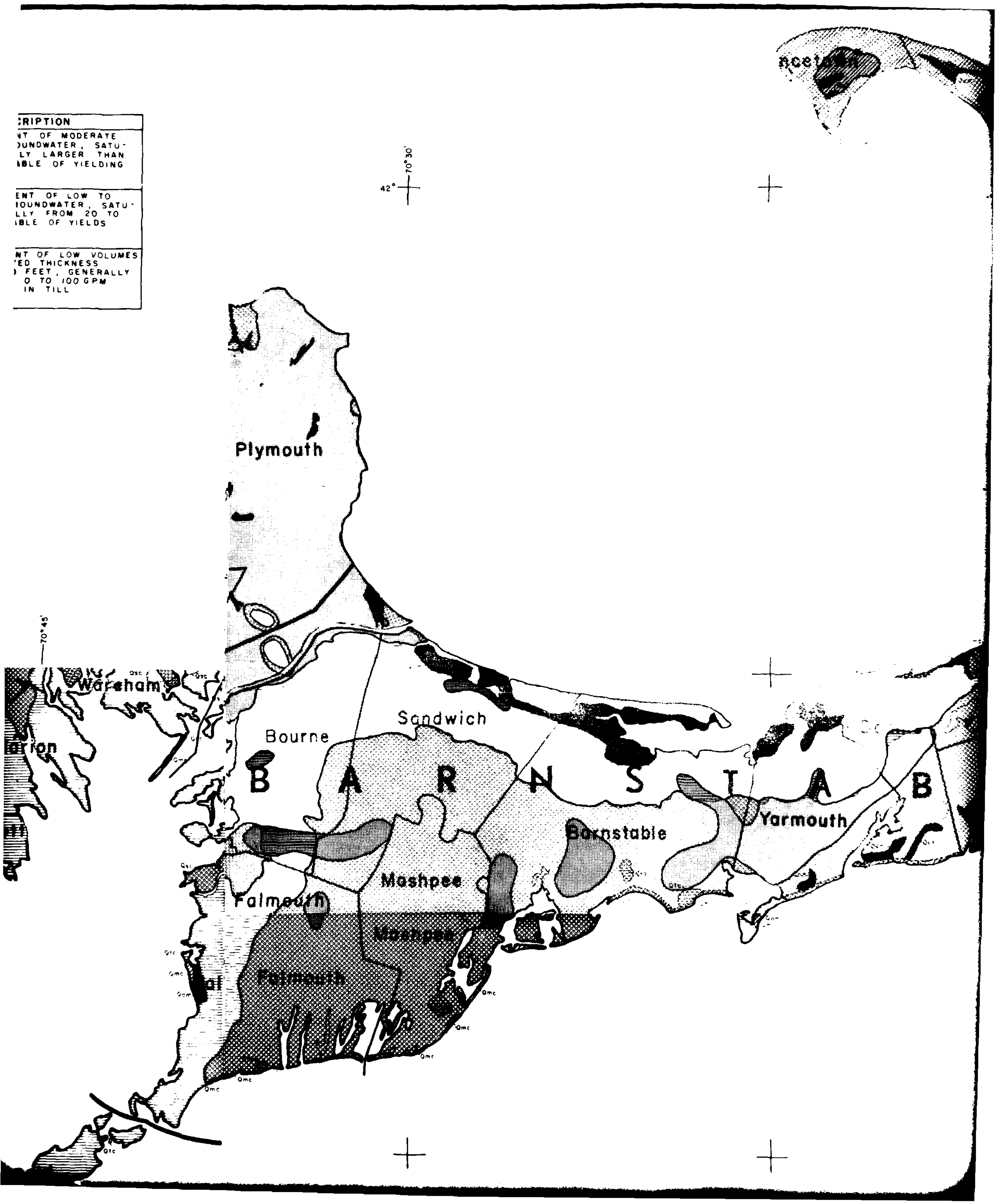
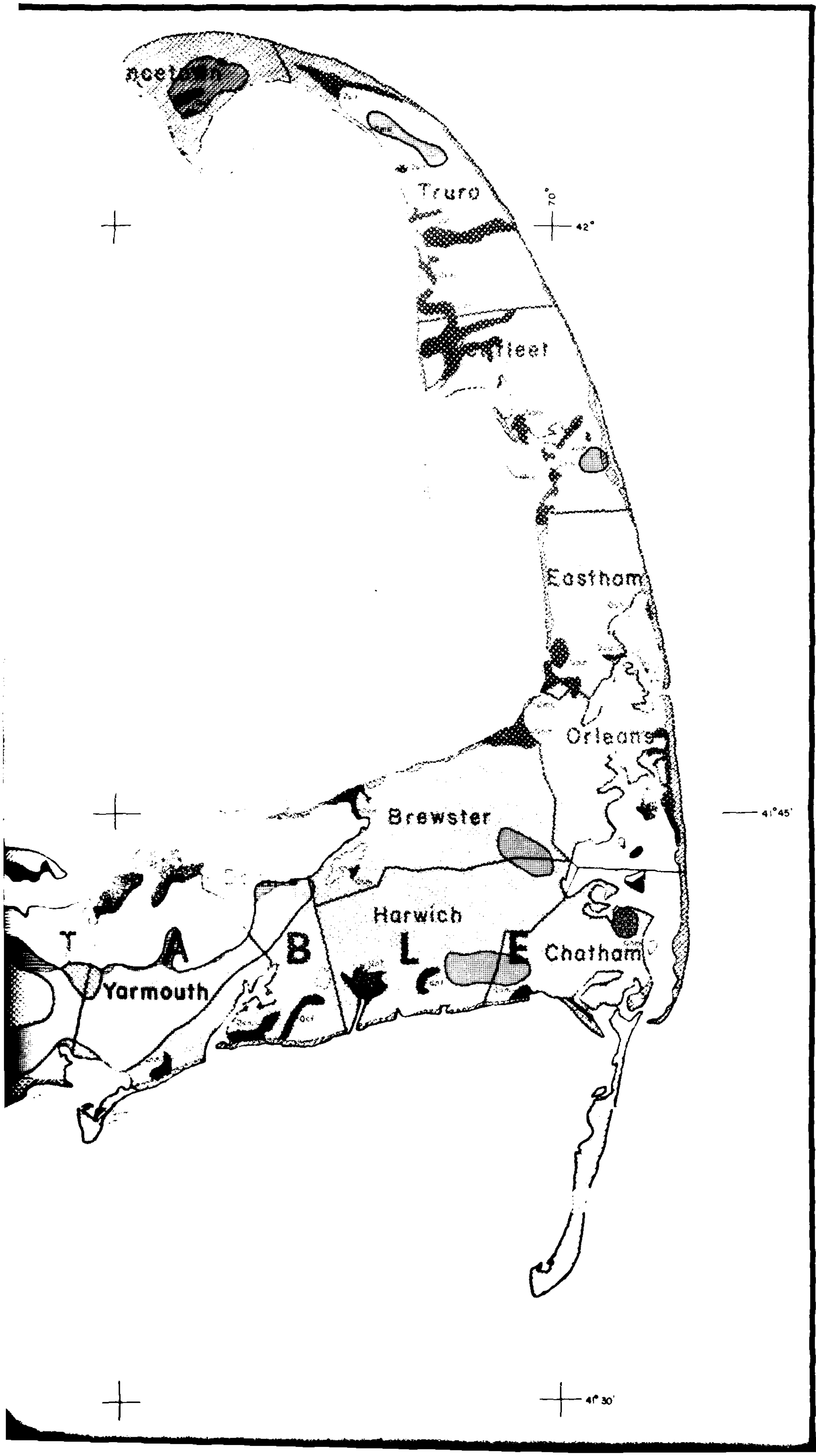
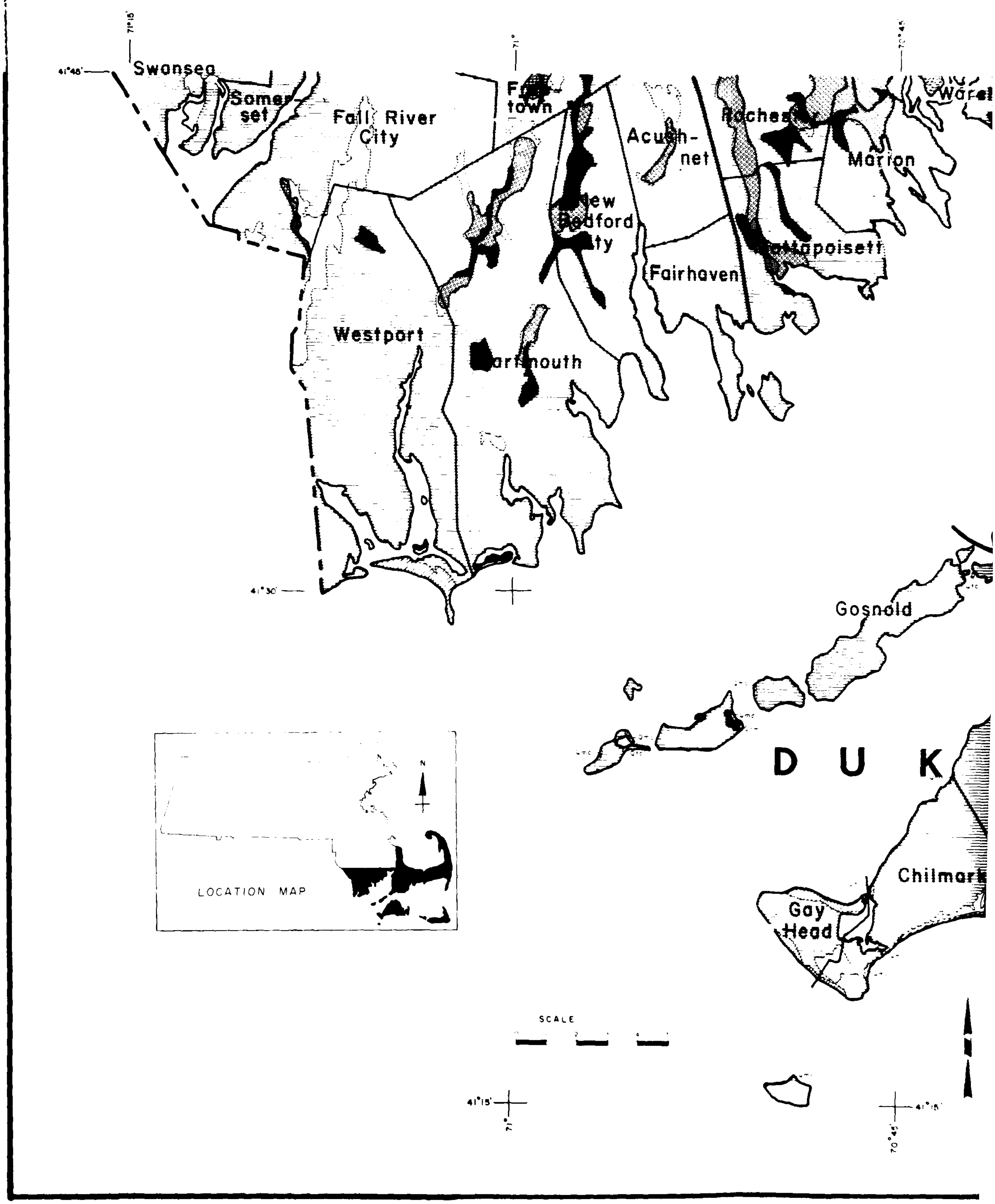




RIPTION
NT OF MODERATE OUNDWATER, SATU- LY LARGER THAN BLE OF YIELDING
ENT OF LOW TO OUNDWATER, SATU- LLY FROM 20 TO BLE OF YIELDS
NT OF LOW VOLUMES ED THICKNESS FEET, GENERALLY 0 TO 100 GPM IN TILL
70°30'
42°
70°45'
Plymouth
Wareham
Bourne
Sandwich
B A R N S T A B
Barnstable
Yarmouth
Mashpee
Falmouth
Mashpee
Falmouth
Qmc

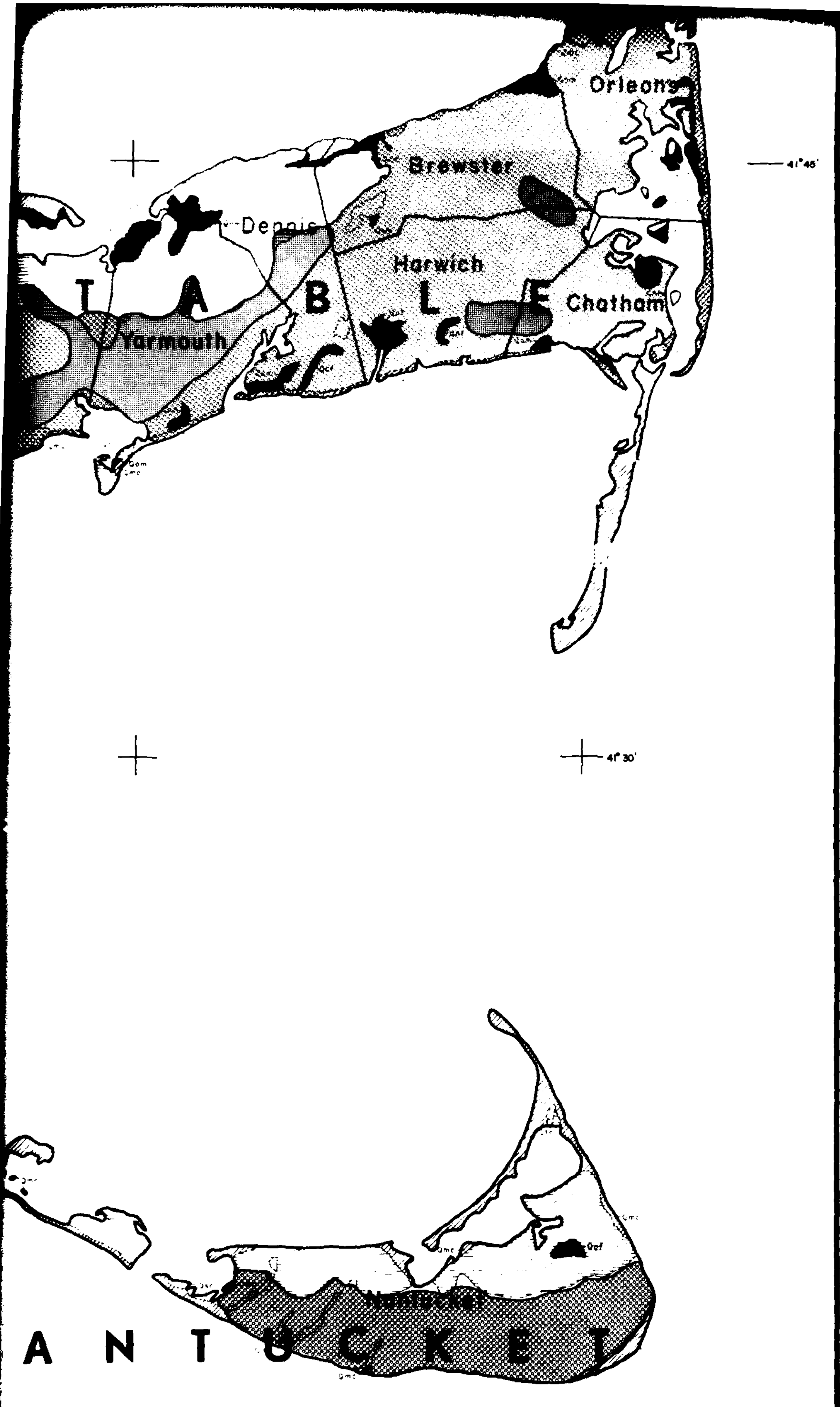

Truro
70°
42°
Eastham
Orleans
41°45'
Brewster
Harwich
Chatham
T A B L E
Yarmouth
41°30'



Swansea
Somerset
Fall River City
Freetown
Acushnet
Rochester
Marion
New Bedford City
Mattapoisett
Fairhaven
Westport
Dartmouth
Gosnold
D U K
Chilmark
Gay Head
LOCATION MAP
N
SCALE
41°45'
41°30'
41°15'
71°15'
71°
70°45'

70°45'
Wareham
Marion
Bourne
Sandwich
BARNSTAB
Yarmouth
Barnstable
Mashpee
Falmouth
Mashpee
Falmouth
Gosnold
Tisbury
Oak Bluffs
UKES
West Tisbury
Chilmark
Edgartown
41°15'
70°45'
41°15'
71°30'
NANTU

15



Orleans
Brewster
Dennis
Harwich
Chatham
Yarmouth
T A B L E
41°45'
41°30'
Nantucket
A N T U C K E T

.6